JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 40 April, 1947 No. 2

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Apple Maggot Control with DDT Sprays and Dusts[1,2]

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Available reports on the efficacy of DDT for the control of the apple maggot have not indicated the invariably high degree of efficiency that this insecticide has exhibited for the control of such an insect as the codling moth with the result that it is, at best, regarded as only promising and, at worst, as a failure. This is all the more surprising when the undoubted effectiveness of DDT against other dipterous species is considered. Data obtained from three years trials of DDT for apple maggot control under both laboratory and field conditions are here presented in the belief that they may help to clarify the status of the material in this respect.

LABORATORY TESTS.—Tests with flies collected from orchard emergence cages were conducted in 1944 and 1946. The flies were held for variable lengths of time in stock cages in the insectary before use. Generally, they were used within a few days of the time of emergence but in some instances they were several weeks old. The numbers employed and proportions of the sexes depended upon the material available.

All spraying and dusting was done in a settling tower consisting of a heavy cardboard cylinder 13 inches in diameter and 72 inches high supported by a framework over a square wooden base chamber in which the object to be treated was placed. An atomizing type of spray nozzle, operated from a compressed air line at 30 pounds pressure, was directed downward from the top center of the tower. A discharge period of 5 seconds filled the tower after which the spray was allowed to settle. In dusting, weighed amounts of the test materials were placed in a suitable discharge tube, located in the base of the tower, from which they could be blown upward by a single puff of air under 15 pounds pressure.

The insecticide was applied to one or more surfaces of the cage in which flies were confined for testing. Three types of cages were used. One consisted of the standard rearing cage, previously described by the writer (1), which has a wooden base and frame covered with cheesecloth on the ends and sides and a sliding glass top about 5 by 8 inches. The toxic material was deposited on one surface of this plate either directly or on top of a dried film of cane sugar which served as a source of food. Water was supplied from small bottles inverted onto filter paper discs in uncovered petri dishes. Another type of cage was of similar construction but the glass plate formed one side, the longer dimension being the height. The third cage used was a petri dish, both halves of which were treated. In it, food and water were supplied as cane-sugar solution placed on a small wad of absorbent cotton.

Petri dish cages were kept in the laboratory but all others were held in the insectary. Examinations were made at daily or shorter intervals and the number and sex of dead flies recorded.

In some tests, the approximate amounts of DDT deposited were measured by placing a weighed glass microscope slide in the settling tower along with the glass plate or petri dish being treated. After drying, the slides were reweighed and the deposit in milligrams per square inch calculated. The relationship between concentration of material used and deposit obtained was found not to be consistent and the values thus obtained must be regarded as of questionable accuracy.

In the 1944 tests, the DDT formula-

[1] Journal Paper No. 687, New York State Agricultural Experiment Station, Geneva, New York (Nov. 27, 1946). This work is part of a cooperative project with the Bureau of Entomology and Plant Quarantine, U.S.D.A.

[2] This paper won for its author the Annual Award of the Eastern Branch for the best paper presented on the program at the annual meeting of the Branch.

tions employed were *Gesarol Spray A20* and *Gesarol Dust A3*. The first trials were made in standard cages with DDT deposited on top of a sugar film so that, in feeding, the flies were forced to ingest the test material and also to walk upon a

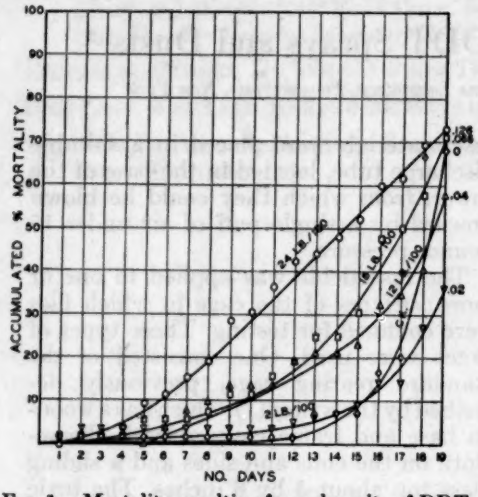

FIG. 1.—Mortality resulting from deposits of DDT in standard cages having glass tops sprayed with *Gesarol Spray A-20* at the rates of 2, 12, 18 and 24 pounds per 100 gallons. Figures in the right-hand margin are approximate deposits of DDT in mg. per sq. in.

sprayed surface. Thirty-five females and 18 males were used in each cage. The results obtained indicate that the exposure to DDT was not sufficient to cause a high mortality rate, even at the highest concentration used, and the tests were discontinued on the nineteenth day (Fig. 1).

Another group of tests was run in upright cages. *Gesarol Spray A20* was applied directly to the glass plate and a sugar smear placed on top of the water bottle to provide unpoisoned food on which the flies could feed without coming in contact with DDT. Twenty-five female and 25 male flies were placed in each cage and the sprayed glass sides turned toward the light to attract the flies to it. While the rate of kill was somewhat greater than in the preceding tests, mortality was low except for the three highest dosages and the tests were terminated on the 13th day (Fig. 2).

Using the same formulation of DDT as in the first group of tests, a series of petri dish cages were sprayed. Eleven female and 4 male flies were used in each test. The flies were in almost continuous contact with a DDT-sprayed surface and complete mortality resulted in much shorter time (Fig. 3).

The effect of increasing the amount of sprayed cage surface is further shown in tests conducted in 1946. Cages similar to the standard cage were used but glass plates replaced the cloth covering except on one end so that from one to four of the cage surfaces could be sprayed. A 50 per cent DDT wettable spray powder (*Deenate 50W*) was used at a concentration equivalent to 2 pounds in 100 gallons. Forty-five flies were placed in each cage for a maximum test period of 7 days. The time-mortality curves obtained show an increased rate of kill when the insects were exposed to more than one sprayed surface (Fig. 4).

The net effect of confining flies to completely sprayed cages is to increase the time they are in contact with DDT. To determine how long an exposure to the

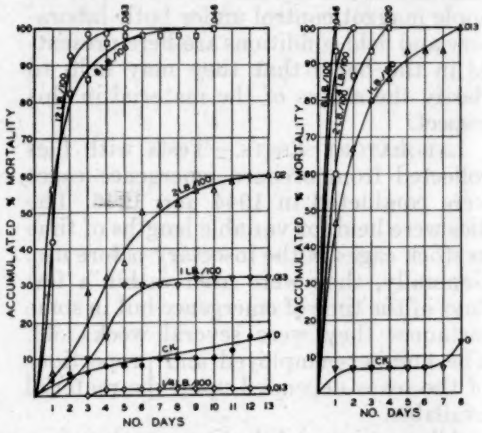

FIG. 2.—Left, Mortality in upright cages having single glass side panels sprayed with *Gesarol Spray A-20* at the rates of 4 oz., 1, 2, 8 and 12 pounds per 100 gallons. Marginal figures are approximate deposits of DDT in mg. per sq. in.

FIG. 3.—Right, Mortality resulting in petri dish cages sprayed with *Gesarol Spray A-20* at the rates of 1, 2, 4 and 8 pounds per 100 gallons. Approximate deposits of DDT in mg. per sq. in. are indicated by figures in the margins.

toxicant is necessary to cause death, the following tests were made in 1946. A group of petri dishes was sprayed in the settling tower with *Deenate 50W* for the same length of time. The deposit was assumed to be approximately the same in each case. Forty-five flies were transferred to each dish and left therein for periods of 5, 10, 15, 30 and 60 minutes, then re-

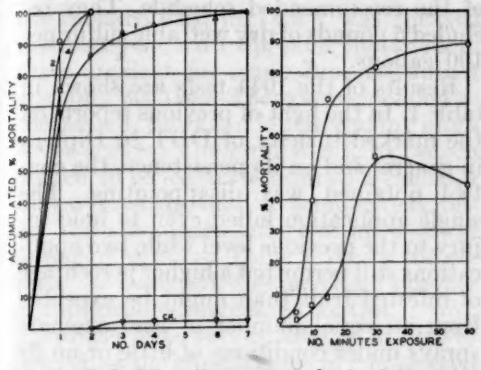

FIG. 4.—Left, Mortality curves obtained in cages having one, two and four sides sprayed with *Deenate 50W* at the rate of 2 pounds per 100 gallons. FIG. 5.—Right, Mortality at 24 hours in flies exposed to DDT deposits for 5, 10, 15, 30 and 60 minutes. Upper line, 2 lbs. actual DDT per 100 gals., lower line, 1 lb. actual DDT per 100 gals.

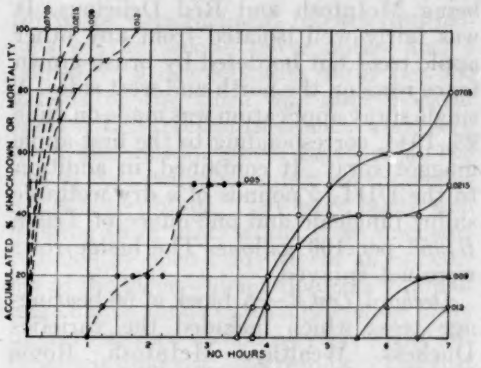

FIG. 6.—Knockdown (broken lines) and mortality (solid lines) resulting in petri dish cages dusted with *Gesarol Dust A-3*. Marginal figures denote approximate DDT deposits in mg. per sq. in.

moved to clean rearing cages and the mortality rate determined over a 10 day period. Although insufficient data have been accumulated to permit the drawing of incontrovertible conclusions, the indications are that even the longer exposures to the DDT deposits employed did not induce a rapid mortality rate. The mortality after 24 hours in two series of tests using the DDT material at the rates of 2 and 4 lbs. in 100 gallons is shown in figure 5. Complete kill within the 10-day test period occurred in only one instance. The exposure period in this case was 30 minutes. No measurement was made of the amounts of DDT deposited by these sprays but they were undoubtedly less than those in earlier tests with petri dish cages.

One group of tests was conducted in 1944 in which petri dish cages were dusted with *Gesarol Dust A3*. Five female and five male flies were used in each test. Both knockdown and mortality were recorded. Mortality was complete within 28 hours or less at all dosages except the lightest. The action of the dust appeared to be more rapid than that of the spray (Fig. 6).

So far as practical use of DDT for apple maggot control is concerned, the laboratory tests showed that the material was toxic to the insect, that it killed at a comparatively rapid rate and that more or less continuous contact with sprayed surfaces for an extended period of time was necessary to cause mortality. This latter could only be obtained, under field conditions, by thorough spray coverage.

FIELD TESTS.—Field control investigations were begun in 1944. More or less isolated test orchards were selected so far as was possible and, as is necessary in apple maggot control experimentation, the entire block was subjected to the same control program. Standard orchard spraying and dusting equipment was used. All spraying was done from the ground with a single nozzle spray gun and the trees were covered both inside and out. Results were measured by examining all fruit from four or more trees, including drop apples other than June drops. An apple showing a single egg puncture, or more than one, was classed as infested. The percentage of infestation thus determined was compared to the infestation of the previous year since it is not feasible to leave unsprayed check trees in apple maggot test blocks.

The DDT formulation used in 1944 and 1945 was a micronized mixture of equal parts of technical grade DDT (*GNB-A DDT*) and pyrophyllite then being used in investigations carried on by the Bureau of Entomology and Plant Quarantine, U.S. D.A. In 1946, commercial wettable spray powders containing 50 per cent DDT were used. In all three seasons, the materials were used at the rate of 2 pounds in 100 gallons of spray.

DDT residues on harvested fruit have been determined by the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine.

Orchard Test 1.—The block of trees used for this test contained 24 bearing-age trees and five small ones, the principal varieties

being McIntosh and Red Delicious. It was fairly well isolated from any other apple trees but bordered by brush-grown fence rows on the north and west sides. A single spray application was made on June 23, 1944, corresponding to the first apple maggot spray. It contained, in addition to the DDT, 5 pounds of a dry wettable sulfur fungicide and one ounce of *Triton B1956* per 100 gallons. The hedge rows were not sprayed.

Orchard Test 2.—A block of 66 bearing-age trees which included the varieties Duchess, Wealthy, McIntosh, Rome Beauty and several unidentified sorts was used in the test. It was partially isolated from other apple trees and surrounded by open fields so that the problem of fly migration was minimized. Two sprays were applied, one on June 22 and the other on July 14, 1944. These corresponded to the first and second maggot sprays of the recommended schedule. They included 5 pounds of dry wettable sulfur per 100 gallons.

Results of the 1944 tests are shown in table 1. In the light of previous reports on the marked toxicity of DDT to Diptera in general and on its persistence, the control obtained was disappointing. The single application failed even to hold injury to the previous level while two applications still permitted a higher percentage of infested fruit than might be expected from an equal number of lead arsenate sprays under conditions of little or no fly migration.

Orchard Test 3.—Since laboratory tests had shown DDT to be very toxic to the apple maggot fly, failure of the material to give control in the field indicated that, under such conditions, its toxicity must be lost at a fairly rapid rate and that additional sprays were needed. Accordingly,

Table 1.—Results of orchard tests with micronized DDT-pyrophyllite (1:1) sprays for apple maggot control.

Test No.	Materials Used in 100 Gallons of Spray	Date of Application	Fruit Examined		Per Cent Infested	DDT Residue gr./lb.
			Variety	Number		
1	DDT-Pyrophyllite 2 lbs.		McIntosh	1668	23.62	0.0035
	Wettable Sulfur 5 lbs.	June 23, 1944	McIntosh	1994	12.69	
	Triton B1956 1 oz.		Red Delicious	1167	81.23	
			Red Delicious	1115	65.11	
			Total	6559		
			Average		35.38	
			1943 Average		10.30	
2	DDT-Pyrophyllite 2 lbs.	June 22 and	Wealthy	4014[1]	30.69	
	Wettable Sulfur 5 lbs.	July 14, 1944	Wealthy	5698[1]	11.92	0.009
			Wealthy	1233	34.47	
			Wealthy	241	38.59	
			McIntosh	5183	11.04	
			Total	16,369		
			Average		25.34	
			1943 Average		95.00[2]	
3	DDT-Pyrophyllite 2 lbs.	June 25,	Duchess	1357	0.00	0.004
	Wettable Sulfur 4 or 5 lbs.	July 7 and	Wealthy	614	1.63	
		July 20, 1945	Wealthy	376	3.46	
			Wealthy	825	1.94	
			McIntosh	734	8.72	
			McIntosh	934	0.96	
			Total	4840		
			Average		2.31	
			1944 Average		25.34	

[1] Includes all drops and 500 picked fruits.
[2] Estimated.

the orchard used in Test 2 was sprayed the next year with the same materials in three applications made June 25, July 7 and July 20, 1945. These corresponded to the second, third and fourth codling moth cover sprays. The crop was light, which tended to concentrate injury on the fruit that did mature and, to some extent, offset the advantage gained from a lower initial infestation. Table 1 shows the results. As expected, the increased number of applications augmented control.

Further tests were conducted in 1946 to determine the effectiveness of commercial formulations of DDT in controlling maggot infestations under particularly adverse conditions.

Orchard Test 4.—A small block consisting of four McIntosh and four Northern Spy trees were sprayed with a wettable spray containing 50 per cent DDT at the rate of 2 pounds per 100 gallons in the second, third and fourth codling moth cover sprays on June 24, July 3 and July 16, 1946. Eight pounds of a wettable sulfur paste were included in each 100 gallons of the second cover spray and 4 pounds of a dry wettable sulfur per 100 gallons of the third and fourth cover sprays. The trees in this block were very large and closely grown together at the top so that complete spray coverage was difficult to obtain. They were fairly well isolated from other apple trees and surrounded by open fields except at one corner of the block which adjoined a group of large maple shade trees. The chance of fly migration was comparatively slight although it did exist. The results of this test are shown in table 2. Control was quite satisfactory despite the problem of spray coverage. In 1945, the fruit of both McIntosh and Northern Spy trees averaged more than 50 per cent infested. However, since the Northern Spy crop in 1946 was very light, fruit examinations were confined to McIntosh and the average percentage of infestation in this variety only taken as a measure of maggot injury in 1945. The potential infestation for 1946

Table 2.—Results of orchard tests with commercial 50 per cent DDT wettable spray powders for apple maggot control.

Test No.	Materials Used in 100 Gallons of Spray	Date of Application	Fruit Examined		Per Cent Infested	DDT Residue gr./lb.
			Variety	Number		
4	*Gesarol AK50* 2 lbs.	June 24,	McIntosh	1867	0.53	
	Wettable Sulfur Paste 8 lbs.	July 3 and	McIntosh	3034	1.35	
	or	July 16, 1946	McIntosh	4618	0.91	0.026
	Dry Wettable Sulfur 4 lbs.		McIntosh	2977	0.33	
			Total	12,865		
			Average		0.84	
			1945 Average		32.15	
5	*Deenate 50W* 2 lbs.	June 24,	McIntosh	1315	4.26	
	Wettable Sulfur 5 lbs.	July 3 and	McIntosh	1858	21.20	0.032
		July 13, 1946	Baldwin	3187	59.33	
			Baldwin	576	30.73	0.027
			Total	6936		
			Average		36.30	
			1945 Average		95.00[1]	
6	*Deenate 50W* 2 lbs.	June 24,	Baldwin	2641	15.67	0.030
	Wettable Sulfur 5 lbs.[2]	July 3,	Jonathan	1398	8.08	
		July 13 and	Jonathan	1852	8.80	0.053
		July 25, 1946	Jonathan	3758	13.81	
			Total	9649		
			Average		12.53	
			1945 Average		95.00[1]	

[1] Estimated.
[2] Omitted July 25.

therefore must be greater than indicated.

Orchard Test 5.—A very heavily infested block containing 19 trees of the varieties McIntosh and Baldwin was sprayed in a similar manner with a brand of 50 per cent DDT wettable powder. The control obtained was less gratifying, as indicated in table 2. This block, although more or less isolated from other apple trees was closely surrounded on three sides by woods. The bordering woodlands were not sprayed and it was apparent that, although protection was provided during the period of heavy fly emergence, there was a great deal of fly movement from the unsprayed woods to the apple trees, which occurred late in the season after the spray deposit had lost its effectiveness. Despite this, there was a reduction in the number of fruits infested and a great decrease in the numbers of egg punctures per fruit.

Orchard Test 6.—On the same farm, a similar orchard of 19 Jonathan and Baldwin trees was given the three sprays listed above for Test 5 and, in addition, was sprayed July 25. This block was in an even worse position with regard to the possibility of fly migration, being almost completely surrounded by woods. The outside trees were partially in the woods and some outlying trees were actually within them. The bordering woodland was not treated. Under these severe conditions, the four applications reduced the heavy infestation greatly with, again, a great reduction in the number of egg punctures per fruit.

Orchard Test 7.—DDT in dust form was employed in the last of the field tests. Four to five applications of a 5 per cent DDT dust were made at 8-day intervals on June 24, July 2, July 10, July 18 and July 26. The diluent used was talc. The orchard consisted of two more or less distinct blocks, the largest of which contained 51 trees of bearing age of the varieties McIntosh, Jonathan and Red Delicious, while the other contained 22 scattered apple trees of various varieties, the majority being Yellow Transparent, together with some plum, pear and cherry trees. The orchard was surrounded by large maple shade trees on three sides and adjoined a DDT-sprayed apple orchard on the fourth. There was some opportunity for movement of flies to and from the shade trees but no sources of outside infestation.

The larger block was dusted five times while the smaller block containing the earliest varieties received four applications, harvesting operations having been started there prior to the July 26 treatment. The trees were dusted from two opposite sides in the early morning, usually under still air conditions although not always when wet with dew. The results, based on examination of all fruit from 10 trees, are shown in table 3. Under the conditions of the test, DDT applied as a dust gave satisfactory control of apple maggot.

The field tests, in general, show that DDT, in either spray or dust form, gave good control of the apple maggot when properly applied but that the period of protection afforded was much shorter than reports on DDT as a household or barn spray would lead one to expect. The effect of a DDT application does not persist as long as does that of one lead arsenate application since two lead arsenate sprays constitute the usual apple maggot control program, while at least three DDT sprays are needed. The lethal action of DDT, on the other hand, is much more rapid than that of lead arsenate. The rapid kill resulting from DDT is of value where fly migration into the orchard may occur since migrating flies must be killed as rapidly as possible to prevent their infesting fruit. Lead arsenate kills so slowly that many eggs may be laid before the fly is poisoned. On the other hand, the short period of effectiveness of DDT necessitates additional applications of this material where fly migration occurs since protection is needed not only during the period of fly emergence but also during that of fly migration, which extends later into the season.

Under present spray residue tolerances, DDT may be used for the control of apple maggot in early varieties with greater safety than lead arsenate. To date, three sprays of DDT at the rate of 2 pounds of a 50 per cent wettable powder in 100 gallons have left toxic residues on early-harvested apples below the present tentative limit.

CONCLUSIONS.—DDT spray and dust residues are toxic to apple maggot flies and killed at a rapid rate. Under field conditions, they afford protection over a shorter period than lead arsenate. The period of effectiveness appears to be about

Table 3.—Results of orchard tests with 5 per cent DDT dust for apple maggot control.

Test No.	Materials Used in 100 Pounds of Dust	Date of Application	Fruit Examined		Per Cent Infested	DDT Residue gr./lb.
			Variety	Number		
7a	*Deenate 50P* 10 lbs.	June 24,	Yellow Transparent	1,967	0.05	
	Talc 90 lbs.	July 2,	Yellow Transparent	2,445	0.00	
		July 10 and	Gravenstein ?	1,409	0.00	
		July 18, 1946	Winter Pearmain	3,508	3.16	
			Winter Pearmain	4,760	6.11	
			Total	14,089	——	
			Average		2.86	
			1945 Average		40.00[1]	
7b	*Deenate 50P* 10 lbs.	June 24,	McIntosh	3,758	0.03	0.020
	Talc 90 lbs.	July 2,	McIntosh	3,309	0.12	
		July 10,	Red Delicious	2,419	0.04	
		July 18 and	Jonathan	2,454	0.20	
		July 26, 1946	Jonathan	1,334	5.40	0.012
			Total	13,274	——	
			Average		0.62	
			1945 Average		25.00[1]	
			Entire orchard:			
			Total	27,363		
			Average		1.78	

[1] Estimated.

two weeks for sprays applied at the rate of 1 pound of actual DDT per 100 gallons and three DDT sprays are needed where two lead arsenate applications would be used. To insure maximum speed of kill thoro spray coverage is essential. All trees within the orchard and all bordering woodlands and hedgerows should be sprayed as is recommended when lead arsenate is used. Where migration of flies from nearby unsprayed trees occurs, DDT applications should be made later in the season than is customary when following a lead arsenate program.—11-21-46.

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Note for Journal of Economic Entomology

Mr. Stephen S. Easter, War Department Entomologist, Headquarters, Second Army, Office of the Engineer, has obtained a leave of absence to serve as Entomologist for the Food and Agriculture Organizations of the United Nations. His immediate assignment is the organization of an international conference scheduled to be held in London, England in August 1947 on the conservation and protection of food against losses from insects, rats, and storage molds.

Liquefied Gas Aerosols for Pea Aphid Control: Third Report[1,2]

L. P. Ditman,[3] Floyd F. Smith,[4] and George Burkhardt[5]

The investigations on the effectiveness and practicability of liquefied gas aerosols for commercial control of the pea aphid have been carried on over a period of three seasons. In the first year's work (Ditman *et al.* 1945), it was found that DDT applied in liquefied gas solution was highly effective against this insect and that the cost would not be excessively high. The following year apparatus of sufficient size for large scale tests was developed (Ditman *et al.* 1946), and favorable results were again secured. The past season's work involved primarily the carrying out of a complete commercial operation. It was thought that before the aerosol method could be recommended to growers, it should be tested under commercial conditions to observe dispenser performance, effectiveness of treatment, and general practicability of the method. The work was conducted on fields of peas made available through the cooperation of two canners on the Eastern Shore of Maryland, the first[5] at Ridgely, involving a total planting of 700 acres, the second[6] at Easton, in which 120 acres were treated. This work was carried out by the authors or by labor directly under their supervision. The operation involved compounding of solutions, filling containers, applying the insecticide in the field and observing results.

Compounding Solutions.—The standard solution employed in most of the commercial treatments was composed (by weight) of DDT, 5 per cent; *Velsicol AR-60*, 5 per cent; cyclohexanone, 5 per cent; acetone, 35 per cent; and *Freon-12*, 50 per cent.[7] A small amount of solution containing methyl chloride instead of *Freon-12* was used to compare the effectiveness of these two propellent gases.

The liquefied gas insecticide solutions were prepared at the canning plant. The operation was found with a little experience to be both rather rapid and simple. As much as 2 tons, or enough to treat 400 acres, was prepared by two men in a single day. The following equipment was found useful: an aspirator, for a 0.75 inch water faucet, equipped with a vacuum gauge (Fig. 1); two clean, empty steel barrels, each with one head removed,

Fig. 1.—Apparatus for evacuating refrigerant tanks preparatory to filling with aerosol solution consisting of an ejector type of pump on water hydrant, filter flask and vacuum gauge in box, and connections to tanks.

for mixing non-volatile ingredients; a rack for holding barrels of ingredients so that the contents could be drawn off by means of faucets (Fig. 2); and three sets of platform scales, one for weighing non-volatile ingredients and two for filling cylinders with non-volatile solution and liquefied gas. These greatly facilitated the work as the three steps were carried on simultaneously. An electric hoist for inverting the liquefied gas cylinder (Fig. 2) was a great convenience. An iron band just large enough to fit over the liquefied gas cylinder and equipped with a hook was useful in attaching the cylinders to this hoist. Necessary hoses, adapters for fitting hoses to tanks, containers for weighing ingredients, stirring paddle, and necessary wrenches were provided. An

[1] Results of a cooperative project between the Bureau of Entomology and Plant Quarantine, and the University of Maryland. This constitutes miscellaneous Periodical No. 51, Contribution No. 2033, of the Maryland Agricultural Experiment Station, Department of Entomology.

[2] Eastern Branch Program.

[3] University of Maryland.

[4] *U.S.D.A., Agr. Res. Adm.*, Bureau of Entomology and Plant Quarantine.

[5] Saulsbury Bros., Ridgely, Maryland.

[6] Chas. Wrightson & Sons, Easton, Maryland.

[7] Propylene oxide 0.5 per cent, reducing the acetone to 34.5 per cent, was added to some of the tanks of aerosol to retard corrosive action in the iron cylinders but was found to be unnecessary.

inverted tin can soldered to the end of a brass pipe and covered with a gauze strainer was used for drawing the non-volatile solution from the mixing barrels.

In carrying out the operation of charging a cylinder, it was first partially evacuated (Fig. 1) to about 25 inches below atmosperic pressure which required about 10 minutes. While this was being done, the non-volatile ingredients, usually enough for five or more cylinders, were

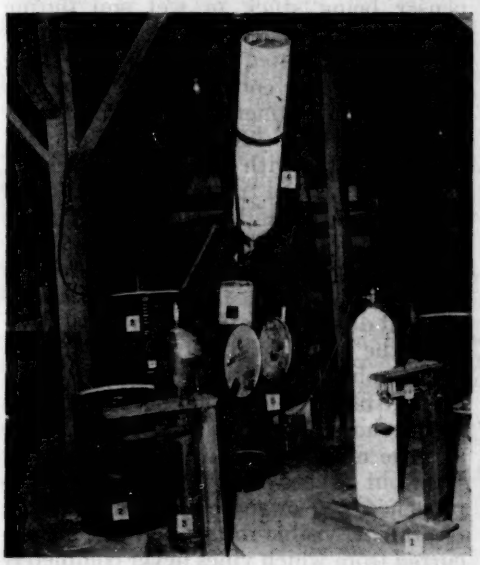

FIG. 2.—Equipment for filling cylinders with aerosol: Tank (1) drawing in non-volatile solution from supply barrels (2). Tank (3) receiving propellent gas from supply tank (4) on hoist. Rack and barrels (5) of solvents for making up non-volatile solutions.

measured out and mixed in one of the open barrels. The evacuated cylinder was moved to one of the scales and the siphon hose connected (Fig. 2). The cylinder was weighed and 50 pounds of non-volatile solution was drawn in. The siphon hose was then disconnected, a hose from the inverted cylinder of liquefied gas was attached, and 50 pounds of *Freon-12* was allowed to enter. The valves were closed and the charged container was disconnected and set aside for use. When methyl chloride was used as a propellant, only 40 pounds of non-volatile ingredients and 40 pounds of methyl chloride, or a total of 80 pounds, were put in a cylinder because this liquefied gas is less dense than *Freon-12*.

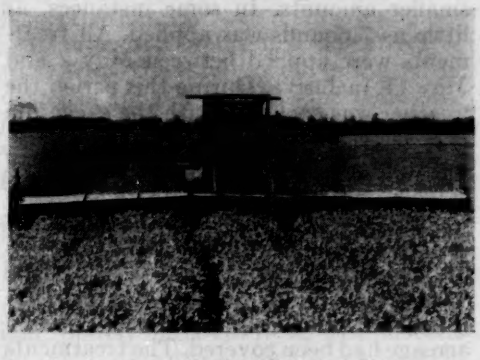

FIG. 3.—Army truck with 24-foot dispenser in operation.

APPLICATION OF INSECTICIDE.—Two dispensers were used in carrying out the work here reported. One (Fig. 3) with a 24-foot boom was constructed by and belongs to the University of Maryland, while the other (Fig. 4) with a 30-foot boom was constructed by the Agricultural Engineering Department of the University. The first was mounted on a four-wheel-drive pickup truck and the other on a half-ton two-wheel-drive pickup truck. Both trucks were equipped to carry four refrigerant gas cylinders containing 100 pounds of *Freon*-DDT aerosol solution, or enough for treating 40 acres of peas. The booms on both dispensers were equipped with 3-gallon-per-hour oil burner nozzles arranged in pairs 3 feet apart in a manner already described (Ditman *et al.* 1945). At atmospheric temperatures of around 70° F. and a speed of 5 miles per hour, aerosol is applied at approximately 10 pounds per acre. Actual atmospheric temperatures during the period of treatment sometimes lower than this resulted in application of

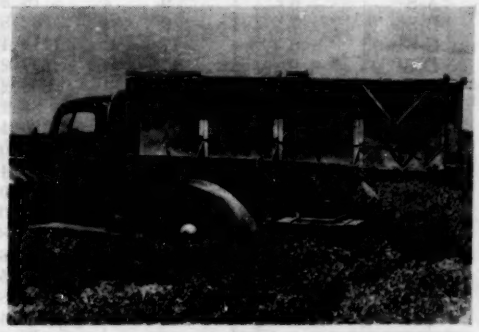

FIG. 4.—Dispenser on pickup truck with wings of 30-foot boom in rack for moving between fields.

smaller amounts. In some instances, as little as 7 pounds was applied. All treatments were applied between May 2 and May 11, inclusive. During this period the weather was cool and, with the exception of one day, windy, with air velocities varying from 10 to 25 miles per hour. Small acreages were treated on May 2 and 3 for the purpose of checking operation of the dispensers. No treatments were made on May 4 and 5, then on May 6 treatments were resumed and continued without interruption until May 11 when the desired acreage had been covered. The treatments of May 2 and 3 were followed by heavy rains.

Untreated check areas were left in all of the larger fields. These were used for determining the insecticide efficiency in reducing aphid populations and, in some instances, for determining effect of treatments on pea yields.

RESULTS AND DISCUSSION.—In evaluating results, it should be remembered that the 1946 season was very favorable to pea production. Conditions were favorable for early planting and the growing season remained cool with ample rainfall. The pea aphid appeared early on peas and, except in a few fields, generally developed to such numbers that the aphids seriously injured untreated peas throughout the area where this work was done.

The first reason for carrying out this project, as already stated, was to determine efficiency of aerosol dispensers when used on a commercial scale. On this point results were gratifying. There was little trouble from nozzle stoppage. In one instance, with the 24-foot machine, 120 acres were treated without a single nozzle stoppage. On neither machine did more than three stoppages, usually due to metal filings left during construction, occur in a single day. The light equipment was found quite satisfactory in wet fields. There was not a single instance of a dispenser being stuck in wet soil during these treatments; in fact, part of the acreage was treated with aerosol because a heavy sprayer could not be taken into the fields. Treatments were rapidly applied, as much as 120 acres being covered in a single day with the 30-foot machine. The DDT aerosol treatments were found effective when wind velocities prevented efficient application of dusts. On only 1 day during the period of treatment was the air sufficiently calm to have allowed efficient dust application.

At the time the treatments were applied, aphid populations varied from an average of 31 to over 300 per sweep. Pea plants showed no visible injury where the average number per sweep was not over 100, but where aphid populations approached 200 or more per sweep before treatment, visible injury had already occurred from which vines never completely recovered even after the number of aphids

Table 1.—Results of Freon-DDT aerosols on the pea aphid.

FARM	DATE TREATED	DATE SAMPLED	APHIDS PER SWEEP		REDUCTION PER CENT OF CHECK	YIELD PER BUSHEL OF SEED PLANTED
			Check	Treated		
	May	May				
A-S	6	9	18.3	8.7	52.4	378.2
B-S[1]	7	9	62.8	17.7	71.8	663.8
C-S[1]	8	17	1414.4	136.4	90.3	649.3
D-S[1]	9	17	2877.2	150.4	94.7	399.7
E-S	8	17	395.2	24.8	93.7	618.4
G-S	11	17	38.2	11.7	69.3	621.1
H-S	8	17	186.4	21.4	88.5	370.2
K-S	9	17	1632.0	60.3	96.3	492.9
L-S	9	17	2598.4	69.3	97.3	483.4
M-S	9	17	1368.0	127.2	91.8	198.6
N-S	10	17	1408.0	67.6	95.2	592.2
O-S	7	17	2380.8	488.0	79.5	511.4
P-S[1]	7	9	30.6	11.5	62.4	578.3
T-S	3	9	33.5	8.7	74.0	540.7
F	7	14	476.8	60.5	87.3	408.6
G	6	14	422.4	11.6	97.3	531.6
H	6	14	659.2	49.1	92.6	350.2

[1] Aphids per sweep at time of treatment: Farm B-S—94; Farm C-S—108; Farm D-S—85.6; Farm P-S—190.4.

had been considerably reduced. The reduction of aphid populations with *Freon* aerosol is shown in table 1.

The effect of treatment on increase in weight of vines and of shelled peas was measured in 10 fields by harvesting small samples from treated and untreated areas. Shelled peas were graded according to size, and the percentages of the various sizes determined by weight. The results of these observations are shown in table 2. There is apparently a rather consistent difference in the maturity in the various fields sampled between treated and untreated peas, the treated peas being immature as compared with untreated peas. An examination of the data (Table 2) shows an apparent relationship between the degree of maturity and the percentage increase in yield of shelled peas of treated areas over checks. Where smaller increases in yield of shelled peas occurred as a result of the treatment, there are generally greater differences in maturity of peas from these treated areas and their respective checks.

Examination of the first fields treated with *Freon*-DDT aerosol did not show the degree of aphid reduction expected on the basis of results in previous seasons' work when methyl chloride had been used as a propellant. Although in later treatments *Freon*-DDT aerosols gave satisfactory population reductions higher than 90 per cent, as compared with untreated checks, comparative tests between methyl chloride and *Freon*-propelled aerosols were immediately initiated. Results of the tests on aphid control in two fields are shown in table 3; and on yield and grade of peas in one field in table 2. Formulated in the same proportions, 50 per cent methyl chloride aerosols gave a better kill of aphids than aerosols propelled by 50 per cent *Freon*.

In one instance where the canner was treating part of his acreage with DDT emulsion sprays, DDT aerosols were ap-

Table 2.—Results of observations on yields of pea vines, shelled peas, and maturity of peas in fields treated with DDT aerosols and emulsions, based on 10 square yard samples.

Farm	Treatment	Green Weight of Vines and Pods	Increase Over Check	Weight of Shelled Peas	Increase Over Check	Per Cent of the Several Sieve Sizes of Harvested Peas[1]					
						1	2	3	4	5	6
		Pounds	Per Cent	Grams	Per Cent						
L-S	Check	17.2	—	1150	—	6	17	36	39	2	0
	Freon	41.3	140.	2020	75.6	15	20	36	27	2	0
C-S	Check	35.5	—	1920	—	10	19	45	24	2	0
	Freon	48.7	37.1	2490	29.7	13	19	38	28	2	0
N-S	Check	36.0	—	2450	—	10	17	35	35	3	0
	Freon	46.1	28.0	2525	3.0	20	20	31	26	3	0
K-S	Check	22.5	—	1410		9	22	40	26	3	0
	Freon	41.3	83.5	2530	79.4	12	13	27	44	4	0
H-S	Check	29.2	—	2120		6	14	33	42	5	0
	Freon	52.8	80.8	3500	65.0	11	18	33	35	5	0
E-S	Check	33.3	—	1845	—	13	29	30	26	2	0
	Freon	40.8	22.5	2100	13.8	20	26	37	16	1	0
	Av. increase		65.3		44.4						
A	Check	18.9	—	1035	—	5	7	25	59	4	0
	Freon	23.4	23.8	1305	26.0	5	8	16	58	10	3
	Emulsion spray	23.6	24.8	1575	52.1	6	17	27	46	3	1
B	Check	35.0	—	1410	—	6	14	28	51	1	0
	Freon	43.0	22.8	1310	7.1	17	26	29	27	1	0
	Emulsion spray	44.2	26.2	1880	33.3	10	17	26	44	3	0
C	Check	29.4	—	530	—	12	20	42	26	0	0
	Freon	32.9	11.9	780	47.1	30	31	23	16	0	0
	Emulsion spray	46.8	59.2	1950	267.9	18	21	24	34	3	0
	Av. increase *Freon*		19.5		22.0						
	Av. increase Emulsion		36.7		117.7						
N	Check	14.2	—	805	—	2	4	28	60	6	0
	Freon	23.8	67.6	830	3.1	8	15	24	46	7	0
	Check	17.9	—	640	—	6	19	45	28	2	0
	Methyl chloride	21.2	18.4	605	5.5	19	23	32	25	1	0

[1] Maturity advances in peas from sieve size 1, the smallest, to sieve size 6, the largest.

Table 3.—Results of tests to determine the comparative toxicity to the pea aphid of *Freon-12*- and methyl chloride propelled aerosols. Date of treatment May 7, of sampling May 11.

Farm	Aerosol Used	Aphids per Sweep		Reduction or Per Cent of Check
		May 7	May 11	
E	*Freon*	187.2	52.0	88
	Methyl Chloride	158.0	32.3	93
	Check	313.0	468.8	—
N	*Freon*		31.4	83
	Check	313.0	188.0	—
	Methyl Chloride		1.7	99
	Check	55.2	126.4	—

Table 4.—Comparative toxicity of DDT-emulsion sprays and Freon-propelled aerosols Treated May 3, sampled May 11.

Farm	Treatment	Aphids per Sweep		Aphid Reduction Per Cent of Check
		May 3	May 11	
A	Aerosol[1]	67.9	24.7	95.1
	Spray		3.3	99.4
	Check	123.2	508.8	
B	Aerosol[1]	56.4	26.5	92.9
	Spray	96.8	16.9	95.5
	Check	81.2	372.8	
C	Aerosol[1]	54.5	14.4	95.5
	Spray	64.0	28.9	91.0
	Check	182.4	320.0	
D	Aerosol[2]	31.7	11.5	88.8
	Aerosol[1]	41.4	7.4	92.8
	Spray	36.7	7.6	92.6
	Check		102.4	

[1] Three-gallon-per-hour nozzles.
[2] Two-gallon-per-hour nozzles.

plied to contiguous areas in the same fields to compare the toxicity of the two materials. Only *Freon*-propelled aerosols were used in these tests and the results are shown in table 4. In both instances 0.5 pound of actual DDT was applied per acre. Though the results show no consistent superiority of either method of application, the canner after the pea harvest felt that the results he secured with DDT emulsion sprays were definitely superior to the *Freon* aerosols. In subsequent small replicate plot tests at the Ridgely Station, emulsion sprays were consistently but not greatly superior to *Freon* aerosol.

The insecticide costs are higher for aerosols than for DDT emulsions or dusts. DDT emulsions can be prepared by the canner at about 50 cents per acre of peas, a 1 per cent DDT-impregnated dust was selling for 4.5 cents per pound or $1.80 for a 40-pound-per-acre application, whereas the materials for preparing the *Freon* aerosols used in the work here were reported to cost approximately $2.25 per acre of peas treated. An additional 15 cents per acre for labor of preparation would be a liberal estimate. The materials for constructing the 30-foot dispenser cost $210, not including labor.

Summary.—Results of the 1946 season's work indicate that *Freon*-propelled-DDT aerosols were slightly inferior to DDT-emulsion sprays and to methyl chloride propelled aerosols. All methods were highly effective against the pea aphid. Aerosol dispensers proved to be efficient, dependable, and rapid in effecting commercial treatments. The light equipment can be used on fields when ground is too wet for a heavy sprayer and under conditions of relatively high wind velocities which would prevent efficient application of dusts. The preparation of aerosol solutions is simple and can be done by the canners at reasonable cost.—11-21-46.

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Control of the Grape Leafhopper[1]

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Since the beginning of grape culture in the Erie Grape Belt the grape leafhopper, *Erythroneura comes* Say, has been one of the major pests of the fruit. For the control of the grape leafhopper during the last 40 years or more, numerous investigators have devoted considerable time and effort in the working out of insecticides and insecticide combinations, as well as in the development of spraying and dusting equipment adapted to this problem. Although considerable progress has been made in methods of control and insecticides used, it must be recognized that the recommended treatments leave much to be desired in the control of the insect.

With this in mind, experiments were started in 1944 to determine the efficiency of a number of insecticides for the grape leafhopper. Preliminary tests with DDT in 1944 (Cox 1945) showed a high degree of control. During the seasons of 1945 and 1946, field tests were carried out to determine the value of DDT and other insecticides for the pest, and to compare nicotine sulphate and DDT in large plot tests for its control. This report gives results of experiments for 1945 and 1946.

METHODS AND MATERIALS.—Tests were conducted in commercial vineyards in the vicinity of North East, Pa. The vineyards were located on sandy and gravelly soils, and were planted to the variety Concord. The vines were trained to the umbrella system. The sprays were applied with a power sprayer and a covered, inverted U-shaped boom (Fig. 1) carrying five nozzles on each side of the row. From 175 to 200 gallons of spray materials were used per acre. All the plots were 12 to 14 rows wide with the exception of the large test plots. The rows were 9 feet apart and ranged from 100 to 120 vines per row. Since there are approximately 600 vines to the acre when planted 8 feet by 9 feet, each plot was about 2 acres in size.

Populations, expressed as the number of leafhoppers per 10 leaves, were determined by the method given by Hartzel & Horsfall (1944). The leaves were collected from 10 vines in the center row of each plot. Only leaves were selected that appeared to be representative of the infestation in a given vineyard. An aliquot fraction of the sample was used to determine the infestation of a plot unless the total catch was less than 100 leafhoppers.

The materials used in the experiments were as follows: nicotine sulphate, 40 per cent nicotine, a miscible oil emulsion[2] containing 20 per cent DDT; a wettable powder[3] containing 40 per cent DDT, a wettable powder[4] containing 50 per cent DDT; a wettable powder[5] containing 25 per cent DDT; a wettable powder[6] containing 50 per cent Hexachlorocyclohexane, a 50 per cent water dispersible powder containing 5 per cent of the gamma isomer; a wettable powder[7] containing 13.5 per cent beta beta dithiocyano diethyl ether; a wettable powder[8] containing 48 per cent sabadilla seed; a miscible oil;[9] viscosity 53 seconds Saybolt at 100° F., unsulfonatable residue 93 per cent; an oil-soluble emulsifying agent.[10]

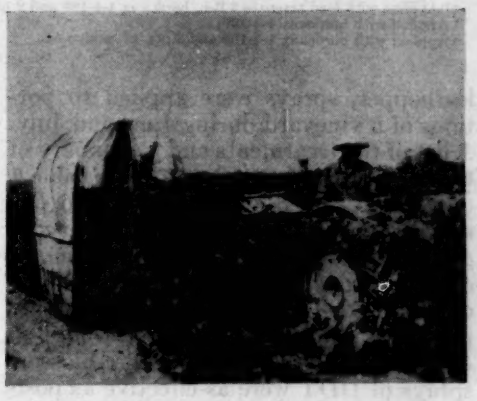

FIG. 1.—Covered, inverted U-shaped boom.

FIELD EXPERIMENTS–1945.—In order to determine the value of pre-blossom and post-blossom sprays for the control of the

[1] Authorized for publication on November 15, 1946, as paper No. 1346 in the Journal Series of the Pennsylvania Agricultura Experiment Station.

[2] *Gesarol Emulsion*
[3] *Gesarol AK-40.*
[4] *Gesarol AK-50.*
[5] *Deenate 25W.*
[6] *Rhothane WP-50.*
[7] *Lethane B-72.*
[8] *Sabacide.*
[9] *Sunoco.*
[10] *Triton B-1956.*

Table 1.—Summary of results of experiments for grape leafhopper 1945.

No.	Treatment Material and amount per 100 gallons	Dates of Application	Leafhoppers per 10 Leaves	
			July 31	Sept. 17
1	*Black Leaf 40*, 12 oz.[1]	July 6 July 18	187	253
2	*Lethane B-72*, 2 lbs.[2]	July 6 July 18	235	410
3	*Gesarol Emulsion*, 2 qts.[3]	June 13	0	0
4	*Gesarol Emulsion*, 2 qts.[3]	July 6	2	0
5	*Gesarol AK-40*, 1½ lbs.[4]	June 13	1	1
6	*Gesarol AK-40*, 1½ lbs.[4]	July 6	0	0
7	*Gesarol AK-40*, 1½ lbs.[4]	June 13 July 6	0	0
8	*Rhothane WP-50*, 1½ lbs.[4]	June 13	1	1
9	Check	——	792	1107

[1,2] Applied with lead arsenate 3 lbs., bordeaux 4-4-100 and 2 qts. of *Sunoco Oil*.
[3] Applied with bordeaux 4-4-100.
[4] Applied with bordeaux 4-4-100 and 2 qts. of *Sunoco oil*.

leafhopper, sprays were applied to portions of a vineyard during June and July. A list of the treatments and a summary of the results are shown in table 1. Table 1 (treatment nos. 3 and 5) shows that one application of DDT, applied to Concord grapes before bloom, gave satisfactory control throughout the season. One application of DDT was as effective as two applications for the control of leafhoppers (treatment nos. 5 and 7). Pre-blossom sprays of DDT were as effective as post-blossom sprays for the control of the leafhopper. One spray of *Rothane*, applied before bloom, gave satisfactory control of the leafhopper. Population counts indicate that nicotine sulphate and *Lethane B-72* greatly reduced the leaf hopper population. However, the leafhoppers built up on the nicotine and *Lethane B-72* plots, and by early September considerable injury was evident on the foliage.

LARGE PLOT TESTS IN 1945.—The favorable results obtained in previous preliminary experiments with DDT warranted the testing of this material on a large scale. Vineyards infested with the grape leafhopper in the vicinity of North East, presented an opportunity to make some large scale comparative tests of DDT and nicotine sulphate for the control of this pest. The four test vineyards were from 10 to 20 acres in size. In each vineyard one half was sprayed with DDT and the other half with nicotine sulphate. The results of the experiments are shown in table 2. It is not necessary to discuss the relative merits of the various tests. However, it should be pointed out that sprays of DDT gave excellent control of the leafhoppers, whereas sprays of nicotine did not give sufficient protection and considerable injury was evident on the foliage in late summer.

FIELD EXPERIMENTS–1946.—During the season experiments were carried out in three vineyards. In one of the vineyards pre-blossom sprays of DDT and hexachlorocyclohexane were applied in June. The results are summarized in table 3 (vineyard A). It may be seen in table 3 that one spray of DDT, applied to Concord grapes before bloom, gave excellent control of the leafhoppers throughout the season. Hexachlorocyclohexane, applied in the pre-blossom spray, did not appreciably reduce the leafhopper population.

In order to secure additional information on post-blossom sprays for the grape leafhopper, tests were carried out in a neglected vineyard that was infested with leafhoppers. A list of the treatments and a summary of the results are shown in table 3 (vineyard B). Sprays of DDT and *Rothane* gave a greater reduction of the leafhopper population than sprays of nicotine sulphate and hexachlorocyclohexane. Sprays of DDT applied at the rate of four ounces per 100 gallons were as effective as sprays of DDT at eight ounces per 100 gallons.

Repeated post-blossom sprays were applied to test plots in another vineyard. A list of the materials and a summary of the results are shown in table 3 (vineyard C). Although there was a light infestation of leafhoppers in this vineyard, three sprays of hexachlorocyclohexane did not satis-

Table 2.—Results of large plot experiments for grape leafhoppers 1945.

Vineyard	Material and Amount per 100 Gallons	Applications	Leafhoppers per 10 Leaves	
			Aug. 10	Sept. 15
A	*Gesarol AK-40*, 2 lbs.[1]	July 6 July 19	0	0
	Nicotine sulphate (*Black Leaf 40*), 12 oz.[2]	July 6 July 19	526	228
B	*Deenate 25-W*, 3 lbs.[1]	July 7 July 22	0	0
	Nicotine sulphate (*Black Leaf 40*), 12 oz.[2]	July 7 July 22	792	687
C	*Gesarol AK-40*, 2 lbs.[1]	July 5	0	0
	Nicotine sulphate (*Black Leaf 40*), 12 oz.[2]	July 5	484	386
D	*Gesarol AK-40*, 2 lbs.[1]	July 8 July 21	0	0
	Nicotine sulphate (*Black Leaf 40*), 12 oz.[2]	July 8 July 21	228	140

[1] Applied with bordeaux mixture 4-4-100 and *Sunoco oil* 2 qts.
[2] Applied with lead arsenate 3 lbs., bordeaux mixture 4-4-100 and *Sunoco oil* 2 qts.

Table 3.—Summary of results of experiments for grape leafhoppers 1946.

No.	Treatment Material and Amount per 100 Gallons	Applications	Leafhoppers per 10 Leaves	
			July 29	Sept. 15
	Vineyard A			
1	*Gesarol AK-50*, 1 lb.[1]	June 21	1	0
2	Hexachlorocyclohexane, 2 lbs.[1]	June 21	411	516
3	Check	——	427	631
	Vineyard B			
4	Nicotine sulphate (*Black Leaf 40*), 1 pt.[2]	July 18	273	320
5	Hexachlorocyclohexane, 2 lbs.[2]	July 18	416	497
6	*Rothane WP-50*, 1 lb.[2]	July 18	1	1
7	*Gesarol AK-50*, ½ lb.[2]	July 18	1	0
8	*Gesarol AK-50*, 1 lb.[2]	July 18	1	1
9	Check	——	566	570
	Vineyard C			
10	Nicotine sulphate (*Black Leaf 40*), ¾ pt.[3]	June 28 July 9		44
11	*Sabacide*, 6 lbs.[4]	June 28 July 9 July 23		12
12	Hexachlorocyclohexane, 2 lbs.[4]	June 28 July 9 July 23		109
13	*Rothane WP-50*, 1½ lbs.[4]	June 28 July 9 July 23		0
14	Check	——		210

[1] Applied with bordeaux 4-4-100 and *Sunoco oil* 2 qts.
[2] Applied with bordeaux 2-2-100 and *Gulf Oil No. 501*, 3 pts. (9 parts oil and 1 part *B-1956*).
[3] Applied with lead arsenate 3 lbs., bordeaux 2-2-100 and 3 pts. *Gulf Oil No. 501* (9 parts oil and 1 part *B-1956*).
[4] Applied with bordeaux 2-2-100 and 3 pts. *Gulf Oil No. 501* (9 parts oil and 1 part *B-1956*).

factorily control the leafhoppers. In the test plots sabadilla reduced the leafhopper population. However, further tests are necessary to finally establish the value of this insecticide for the control of the grape leafhopper.

DISCUSSION.—The data presented in tables 1, 2 and 3 indicate that one spray of DDT, applied at the rate of 4 ounces or more per 100 gallons, will give satisfactory control of the grape leafhopper. Field experiments have shown that pre-blossom sprays of DDT are as effective as post-blossom sprays for the leafhopper. Pre-blossom sprays of DDT, directed against the over wintering adults, appear to be more satisfactory than later sprays in that the leafhopper damage is reduced to a minimum. Observations and population studies indicate that the residual effect of DDT lasts for several weeks. Since sprays of DDT remain toxic to the grape leafhopper for a long time, it might be supposed that the grape absorbs some of the spray. To determine this question grape leafhopper nymphs were caged on the under side of grape leaves that had previously received DDT spray (1 lb. per 100 gallons) only on the top side. The tests were repeated a number of times and the results indicate that the nymphs fed on the treated leaves and completed their development as readily as nymphs that fed on unsprayed grape leaves. No damage to the fruit or foliage of Concord grape was observed where DDT sprays were used. *Rothane* (dichloro diphenyl dichloroethane) appeared to be quite toxic to the grape leafhopper, and one application, applied either in the pre-blossom or post-blossom sprays, gave satisfactory control of the leafhoppers. Population studies indicate that sprays of nicotine sulphate and *Lethane B-72* are effective for the grape leafhopper. However, nicotine sulphate and *Lethane B-72* did not prevent a build-up of the leafhoppers and by early September considerable injury was evident on the foliage. During the season of 1946 sprays of hexachlorocyclohexane did not give adequate control of the grape leafhopper.

SUMMARY.—Field experiments indicate that one application of DDT will give satisfactory control of the grape leafhopper. Sprays of DDT appear to be toxic to the adults as well as the nymphs and the residual effect lasts for several weeks. Early season sprays appear to reduce the leafhopper damage to a minimum. Population studies indicate that sprays of nicotine sulphate and *Lethane B-72* are effective for the grape leafhopper. However, nicotine sulphate and *Lethane B-72* did not prevent a build-up of the leafhoppers and by early fall considerable damage was evident on the foliage. Sprays of *Rothane* gave satisfactory control of the leafhoppers in either the pre-blossom or post-blossom sprays. Experiments for one season indicate that sprays of hexachlorocyclohexane are not effective for the grape leafhopper. No injury to the fruit or foliage of Concord grape was observed where DDT sprays were used.

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ROCKY MOUNTAIN CONFERENCE OF ENTOMOLOGISTS

The 18th Rocky Mountain Conference of Entomologists is to be held at the Cameron Pass Camp, 80 miles west of Fort Collins, Colorado, August 17–21, 1947. The arrangements are such that members of the families can enjoy a mountain outing during the time of the meetings. Those desiring information in regard to the meeting should write the Conference Secretary.

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Pea Aphid Control in Eastern Virginia[1]

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Reports of recent research on the control of pea aphids *Macrosiphum pisi* (Kalt.), show excellent results with some of the new insecticides and new methods of application (Ditman *et al.* 1945; Glasgow 1946; Ditman 1946). In view of these facts it seemed advisable to make tests with some of the new methods and materials in Tidewater Virginia.

Pea aphids were unusually abundant on alfalfa and other legumes during March and migration to peas began the last week of March. This migration was about 3 weeks ahead of the normal season. Heavy rain storms and light freezes during April retarded the aphid development so that populations were not sufficiently large to warrant insecticide applications until the last week of April. The first week of May many fields were heavily infested, some having as many as 500 to 700 aphids per sweep of a 15 inch diameter net. The aphid population remained heavy until the middle of May by which time they had caused heavy damage to untreated peas.

TEST EQUIPMENT.—Dusts were applied with a motor-driven eight-nozzle horse-drawn duster. The nozzles discharged the dust under a 35-foot cloth canopy trailing the duster. For the test on peas sown in rows at Machipango, Virginia, the nozzles were adjusted, two to each of the three middle rows and one to each outside row in the 5-row plats. In the Onley tests on peas sown broadcast the eight fan-shaped nozzles were equally spaced across the 10-foot boom and so arranged as to blow the dust directly down into the vines. Although attempts were made to calibrate the machine for each dust, considerable mechanical difficulty was encountered and the desired amount was not always obtained.

The aerosol machine (Fig. 1), was fabricated in the experiment station shop. It consisted of a light angle iron frame 12 feet wide and 3 feet from front to rear, supported on each side with double duty bicycle wheels. Shafts were attached for convenience in pulling the apparatus. The aerosol cylinder was cradled in a support centrally located on the top side of the frame. The aerosol liquid was fed from the clyinder to a filter and then into a two-way valve from which two lines of quarter inch copper tubing extended the width of the frame. There were six *Edco No. 2.00* oil burner nozzles installed at equal intervals on each of these lines. The nozzles were adjusted to discharge the aerosol into the plants at about a 45° angle from above. In the front line the nozzles were directed towards the rear right side of the machine and the nozzles

FIG. 1.—Liquefied gas aerosol machine used in the pea aphid tests at Machipungo and Onley, Virginia.

[1] Eastern Branch Program.

in the rear line were directed towards the front left side of the machine. The top of the frame was covered with unbleached muslin which extended as a trailer or canopy 6 feet behind the machine. The apparatus was pulled by hand in the Machipango test and by tractor in the Onley test. Calibration of this machine, at the time field applications were made, indicated an approximate output of 1.08 pounds per minute with the two liquified gas formulas used.

The orchard sprayer used in the tests at Onley maintained a pressure of 450 pounds per square inch. It was equipped with a single pipe boom with 10 nozzles spaced at equal intervals across the boom. The nozzles were fitted with No. 3 disks. The output of the machine was 8 gallons per minute. It was pulled by a tractor with the rate of travel adjusted so as to apply 100 gallons per acre.

The atomizer equipment was a specially constructed experimental machine mounted on the rear of a tractor. The boom was 5 feet long and fitted with six special atomizer nozzles. The apparatus operated at an oil pressure of 3.5 pounds and at an air pressure of 12 pounds, and applied 2.5 gallons of oil per acre.[1] A Piper Cub airplane crop duster was used to apply the dust treatments in another test.[2]

METHODS OF TAKING RECORDS.—Aphid populations were determined by two methods. In the Machipango tests on row peas, which were too small for the usual sweeping method, populations were determined by placing a shallow rectangular pan (6 by 30 in. and 0.5 to 1 in. deep) on the ground close to the plants and vigorously shaking the vines over it, then counting the aphids thus collected from the 30 inches of row. Five such samples were taken in each plat for the 1-day count, four samples for the 3-day count and three samples for the 5-day count. All counts were made on the middle three rows of each plat, using a different row each day.

At Onley, aphid samples for counting were taken by making 20 sweeps with a 15 inch net in each plat. Due to adverse weather conditions counts were made only on the fourth and sixth days after treatment.

For the four-day count the aphids were dumped from the net into paper bags. The bags of aphids were then placed in the oven of a kerosene cook stove and held for several minutes at a temperature of 350° F. With a little practice the proper exposure time and temperature can be determined so that the aphids come out in a nice crisp brown condition and are easily separated and counted. The bags of aphids collected for the 6-day record were placed in a quick freezing unit at 20° F below zero for a couple of hours before counts were made. Both methods were very satisfactory but the heat-killed aphids were probably a little easier to separate and count.

Yield records were taken in the Onley Experiment by cutting the entire lot of vines off of each plat and sending the separate lots to a commercial viner where the total weights of shelled peas for each replication were recorded.

All aphid and yield data from the Onley and Machipongo experiments were analyzed by Fisher's method for analysis of variance.

MATERIALS USED.[3]—Each of the following 24 different formulations were used at least once in one test and some were included in several tests.

(1) DDT 1 per cent dust. Made by blending 2 pounds of a 50 per cent DDT dust concentrate with 98 pounds of pyrophyllite.

(2) DDT 1 per cent impreganted (volatile solvent) dust. One pound of DDT dissolved in 3 pounds of carbon tetrachloride then sprayed on to 99 pounds of pyrophyllite while mixing.

(3) DDT 1 per cent impregnated (nonvolatile solvent) dust. One pounds of DDT dissolved in 3 pounds of *Velsicol AR-60* then sprayed on to 99 pounds of pyrophyllite while mixing.

(4) DDT 1 per cent dust plus the nonvolatile solvent. Same as formulae No. 1 plus 3 pounds of *Velsicol AR-60* added near the end of the mixing process.

(5) The same as formulae No. 3 except

[1] This machine belonged to the Shell Oil Co. and was used in the Onley test.

[2] This machine belonged to the Greenwich Air Service and was used on the Dulaney Quick Freeze Co. Farm.

[3] The source of materials are as follows: American Cynamid and Chemical Corp. formulations Nos. 1, 2, 3, and 4. Miller Chemical Co. No. 5. Southern States Coop. Nos. 6 and 7. Pennsylvania Salt Mfg. Co. Nos. 8, 15, 16 and 24. Virginia Smelting Co. Nos. 10 and 11. Rohm and Haas Co. No. 13. California Spray-Chemical Corp. No. 17. Tobacco By-Products & Chemical Corp. Nos. 18 and 19. Shell Oil Co. Nos. 21, 22 and 23.

obtained from a different commercial insecticide manufacturer.

(6) DDT 1 per cent impregnated (nonvolatile solvent) dust. Made by spraying 3.46 pounds or 0.4 gallon (2.5 pounds of DDT per gallon) of a 30 per cent DDT-oil (alkylated naphthalene type of oil) concentrate onto 90 pounds of pyrophyllite and seven pounds of bulking agent.

(7) DDT 1 per cent impregnated (nonvolatile solvent) dust plus *Lethane A-70*. The same as formulae No. 6 except that *Lethane* was added at close of mixing.

(8) DDT 3 per cent impregnated (nonvolatile solvent) dust. Three pounds of DDT dissolved in 2 pounds of *Velsicol AR-60* plus carbon tetrachloride then sprayed onto 95 pounds of clay.

(9) DDT 5 per cent liquefied gas aerosol. Acetone 34.5 per cent, propylene oxide 0.5 per cent, cyclohexenone 5.0 per cent, DDT 5.0 per cent, *Veliscol AR-60* 5.0 per cent and *Freon-12*, 50.0 per cent.

(10) DDT 5 per cent liquified gas aerosol. Acetone 22.0 per cent, methylene chloride 5.0 per cent, lubricating oil 10W 5.0 per cent DDT 5.0 per cent and methyl chloride 63.0 per cent.

(11) Rotenone 1 per cent dust. One pound of cube (5 per cent rotenone) to 4 pounds of pyrophyllite.

(12) Rotenone 0.5 per cent dust. One pound of cube (5 per cent rotenone) to 9 pounds of pyrophyllite.

(13) Rotenone 0.5 per cent plus 1 per cent *Lethane B-71* dust.

(14) Rotenone 0.5 per cent plus 2 per cent oil. One pound of cube powder (5 per cent rotenone) mixed in 0.2 pound of 20W lubricating oil, then blended with 9 pounds of pyrophyllite.

(15) Benzene hexachloride (0.225 per cent gamma isomer) dust. Made by mixing 0.75 pound of benzene hexachloride (30 per cent gamma[1]) with 99.25 pounds of clay.

(16) Benzene hexachloride (0.9 per cent gamma) dust. Three pounds of benzene hexachloride (30 per cent gamma) and 97 pounds of clay.

(17) Benzene hexachloride (0.6 per cent gamma) dust. Five pounds of benzene hexachloride (12 per cent gamma) and 95 pounds of clay.

(18) Benzene hexachloride (0.75 per cent gamma) dust plus 3 per cent nicotine. Made from *Black Leaf Dry Concentrate-Y* (containing 12 per cent nicotine in the salt form and 3 per cent of the gamma benzene hexachloride) 1 pound to 3 pounds of pyrophyllite.

(19) Nicotine 3 per cent plus 2 per cent oil. Thirty pounds of *Black Leaf 10*, 2 pounds of light lubricating oil, and 68 pounds of pyrophyllite.

(20) Cube powder (5 per cent rotenone) 6 pounds to 1 quart of *Red A* soap to 100 gallons of water.

(21) DDT 2.5 per cent oil emulsion (2.5 gallons to 100 gallons of water). Made from an oil emulsion concentrate containing 0.2 pound of DDT per gallon.

(22) DDT 25 per cent oil emulsion (0.25 gallon to 100 gallons of water). Made from *ACX-208* an aromatic oil emulsion concentrate containing 2.0 pounds of DDT per gallon.

(23) DDT 2.5 per cent atomizing oil. A base oil containing 0.2 pound of DDT per gallon. Used undilute applying 2.5 gallons per acre.

(24) DDT 50 per cent wettable powder. Applied at the rate of two pounds to 100 gallons of water per acre.

MACHIPONGO EXPERIMENTS.—The field selected for this test was a uniform planting of sweet peas in rows 21 inches apart. At the time of treatment the plants were about 10 inches tall and had not bloomed. All plats were approximately 200 feet long. The dust machine covered five rows and the aerosol machine covered seven. Each treatment and check was replicated three times. The treatments were made on April 30, 1946 between 10:00 AM and 5:30 PM. Weather records were taken at intervals throughout the time of treatment. The temperature was 76° F. in the morning and dropped to 70° by 1:00 PM where it stayed most of the afternoon, dropping again at the close of treatment time to 65°. Relative humidity ranged from 60 to 70 per cent during most of the time and jumped to 84 per cent at the close of treatment time. The wind was blowing almost lengthwise of the plats and varied from 2 to 3 miles per hour all day, increasing to 5 miles per hour at the close of the test. The sky was overcast. A heavy rain storm occurred between the 1 and 3 day aphid counts.

The different materials tested, rates of application and results obtained are given in table 1. The records taken show that all treatments gave a significant decrease

[1] "Gamma" used to indicate gamma isomer.

Table 1.—Results of treating row sweet peas for the control of the pea aphid at Machipongo, Virginia, April 30, 1946.

Formulation No.[1]	Materials Used	Lbs. per Acre	Average No. Aphids per 2.5 Ft. of Row & Per Cent Kill After Treatment					
			1 Day		3 Days		5 Days	
			No.	%	No.	%	No.	%
1	1% DDT (Regular mix)	62	226	67	212	22	124	63
2	1% DDT Impregnated (Volatile Solvent)	62	244	64	156	42	112	66
3	1% DDT Impregnated (Non-Volatile Solvent)	50	65	90	42	84	75	77
4	1% DDT (Regular mix)+(Non-Volatile Solvent)	48	69	90	62	77	48	86
5	1% DDT Impregnated (Non-Volatile Solvent)	75	34	95	20	93	18	95
6	1% DDT Impregnated (Non-Volatile Solvent)	58	65	90	30	89	28	92
7	1% DDT Impregnated (Non-Volatile Solvent)+2% *Lethane A-70*	64	111	84	60	78	56	83
8	3% DDT Impregnated (Non-Volatile Solvent)	50	72	89	19	93	25	92
9	5% DDT Liquefied Gas Aerosol	20	339	50	92	66	64	81
10	5% DDT Liquefied Gas Aerosol	10	449	34	136	50	149	55
11	1% Rotenone	45	330	51	67	75	114	66
12	0.5% Rotenone	60	409	40	91	66	118	65
13	0.5% Rotenone+1% *Lethane B-71*	60	337	50	107	60	99	70
14	0.5% Rotenone+2% oil	50	329	52	122	55	137	59
15	Benzene hexachloride (0.225% gamma)	50	309	54	49	82	90	73
16	Benzene hexachloride (0.9% gamma)	41	72	89	5	98	10	97
17	Benzene hexachloride (0.6% gamma)	58	80	88	28	90	8	98
18	Benzene hexachloride (0.75% gamma)+3% Nicotine	71	14	88	14	95	8	98
19	3% Nicotine+2% oil	11	376	45	57	79	125	62
	Untreated Check	—	679	—	270	—	333	—
	Difference required for significance (19 to 1 odds)		113		78		90	

[1] Formulation No. for convenience in finding, in the text, a more detailed description of the materials used.

in aphid population. Comparisons of different DDT formulations show that in the 1- and 3-day counts the impregnated DDT dusts, if properly formulated, were significantly better than the regular mixed DDT dusts without oil. There was no significant difference between the regular mixed DDT dust to which a non-volatile solvent had been added, and the impregnated dust made with a non-volatile solvent. DDT-impregnated dust in which a volatile solvent was used was no better than the regular mixed DDT dust. The 3 per cent impregnated DDT seemed to be no more effective than the 1 per cent impregnated dust. The 1 per cent DDT impregnated dust using the non-volatile solvent seems to be the most practical and efficient of the DDT dusts tested. There seemed to be little difference in the performance of the impregnated DDT dusts obtained from different sources.

The 5 per cent DDT liquefied gas aerosol at the light dosage was inferior in most instances to the better 1 per cent DDT impregnated dusts. The heavy application of aerosol was not much better than the light application.

In the rotenone bearing dusts that were tested, there appeared to be no significant differences between the 1 per cent and the 0.5 per cent concentrations or those with and without oil or *Lethane* conditioners.

The benzene hexachloride dusts containing from 0.6 to 0.9 per cent gamma isomer appeared to give excellent control of the pea aphids in all instances. The benzene hexachloride dust containing 0.225 per cent gamma isomer appeared somewhat less effective. The addition of 3 per cent nicotine did not significantly increase the effectiveness of the benzene hexachloride. The 3 per cent nicotine plus 2 per cent oil dust had such poor dusting qualities that only 11 pounds per acre was applied and therefore it is not comparable to the other treatments.

Due to the apparent variability of the aphid population in the field, especially by the time the 5-day count was made, it

is difficult to show significant differences between DDT, rotenone-bearing and benzene hexachloride dusts. However, if the DDT, benzene hexachloride and rotenone-bearing dust treatments with the more uniform records are analyzed separately there are some significant differences between them, the rotenone-bearing dusts being significantly poorer and the benzene hexachloride dust being on the border of significantly better than the DDT.

ONLEY EXPERIMENTS.—The field used for the test at Onley was a uniform broadcast planting of Thomas Laxton peas. The plants were about 15 inches tall and were beginning to bloom at the time of treatment on May 2, 1946. All plats were 180 feet long and 10 feet wide, with a 2-foot alley between plats. Each treatment was replicated four times in randomized blocks. Treatments were made between 1:00 and 5:00 PM. The temperature was 75° F. most of the day, dropping to 70° F. the last half hour of treatment time. The relative humidity was 75 to 85 per cent, followed by a mist and light drizzle at the close of the test, and a heavy rain within 20 minutes after the last treatment was applied. The wind velocity was less than 4 miles per hour all afternoon and usually was near 2 miles.

The different materials tested, rate of application and the results obtained are given in table 2. All treatments resulted in highly significant reductions in aphid population and increases in yield. The results obtained with the 1 per cent DDT regular mixed dust and the 1 per cent DDT impregnated dust made with a volatile solvent were not significantly different in aphid control or yield. However, both of these treatments were significantly poorer in aphid control and yield than the 1 per cent DDT impregnated dust made with the non-volatile solvent and the 1 per cent DDT regular mixed dust to which the non-volatile solvent had been added. These results agree with those obtained with the same DDT dusts in the Machipongo test. In the DDT spray tests the wettable powder spray performed very poorly while the DDT oil emulsion sprays gave excellent con-

Table 2.—Results of treating broadcast Alaska peas for the control of pea aphids at Onley, Virginia. Treated May 2, harvested May 28–29, 1946.

Formulation No.[1]	Material Used	Amount of Material per Acre		Aphids 6 Day		Yield of Shelled Peas, Lbs. per Acre
		Lbs. Dust	Gal. Spray	Av. No. per sweep	Reduction Per Cent of Check	
1	1% DDT (regular mix)	53	—	310	57	696
2	1% DDT impregnated (volatile solvent)	54	—	308	57	653
3	1% DDT impregnated (non-volatile solvent)	36	—	54	92	1307
4	1% DDT (regular mix)+(non-volatile solvent)	23	—	88	88	1041
24	50% DDT wettable powder (2 Lbs. to 100 gal. water)	—	100	226	68	678
21	2.5% DDT oil emulsion concentrate (2.5 gal. to 100 gal. water)	—	100	22	97	1083
22	25% DDT oil emulsion concentrate (0.25 gal. to 100 gal. water)	—	100	42	94	1301
23	2.5% DDT atomizing oil	—	2.5	122	83	1041
11	1% Rotenone (made from cube containing 5% rotenone)	43	—	118	83	895
20	Cube (5% rotenone)—*Red A Soap* (6 lbs. to 1 qt. to 100 gal. water)	—	100	53	93	986
18	Benzene hexachloride (0.75% gamma)+3% nicotine	42	—	116	84	950
16	Benzene hexachloride (0.9% gamma)	53	—	7	99	1519
	Untreated Check	—	—	714	—	284
Differences required for significance (19 to 1 odds)				76	—	188
Differences required for significance between treatments that have over 90% aphid control (19 to 1 odds)				14		

[1] Formulation No. for convenience in finding, in the text, a more detailed description of the materials used.

trol. The DDT oil emulsion spray made from the 2.5 per cent concentrate gave a slightly better aphid control but a significantly lower yield than did the DDT oil emulsion spray made from the 25 per cent concentrate. This yield difference is probably due to the stunting of the plants that was caused by the excessive amount of oil in the 2.5 per cent mixture. The 2.5 per cent DDT atomized oil treatment gave significantly lower aphid reductions than did either of the oil emulsion sprays, also it resulted in a significantly lower yield than did the 25 per cent DDT oil emulsion treatment.

The rotenone-bearing spray was almost as effective as the best DDT sprays and dusts in aphid control. The rotenone-bearing dust was significantly less effective than the rotenone spray in aphid control. Both rotenone-bearing spray and dust treatments were significantly lower in yield than the best DDT spray or dust treatments.

The benzene hexachloride (0.75 per cent gamma isomer)-3 per cent nicotine dust was about equal in effectiveness to the 1 per cent rotenone-bearing dust. The benzene hexachloride dust, 0.9 per cent gamma, was significantly better than all other treatments in aphid control and yield. Two different lots of peas from the benzene hexachloride treated plants were canned at the time of harvest and no objectionable odor was detected in any of these peas.

Four DDT liquefied gas aerosol treatments were made in this experiment but space permitted only a single plat for each treatment so the data could not be analyzed with the other 12 treatments. The aerosol treatments were 5 per cent DDT in *Freon 12* (Formulation No. 9) applied at two dosages, and 5 per cent DDT in methyl chloride (Formulation No. 10) applied at two dosages. The plat treated with the *Freon 12* mixture at 20 pounds per acre had an average of 60 aphids per sweep which was 91 per cent control compared with the check area. It yielded 1089 pounds of shelled peas per acre. The DDT *Freon* aerosol at 10 pounds per acre had 136 aphids or 85 per cent control and a yield of 920 pounds. The methyl chloride aerosol at 20 pounds per acre had 7 aphids or 99 per cent control and yielded 1573 pounds. The methyl chloride at 10 pounds per acre had 106 aphids or 85 per cent control and yielded 1186 pounds.

Samples of pea vines from several of the DDT treated plats were sent to the United States Department of Agriculture for DDT analysis.[1] It is interesting to note that no DDT residue was detected on the plats treated with 1 per cent DDT impregnated dust, and none where the DDT-methyl chloride aerosol mixture was used. The plants treated with the DDT- *Freon 12* aerosol at 20 pounds per acre had 8.6 parts of DDT per million parts of dry vine weight, and the vines receiving the 10 pound application had 3 parts per million. Also, where the DDT wettable powder, DDT 25 per cent oil emulsion concentrate and the 5 per cent DDT atomized oil were used, DDT residues were found in amounts of from 0.4 to 0.8 parts per million.

AIRPLANE TESTS.—Observations were made on airplane applications of insecticides on several commercial pea fields. In most instances a 1 per cent impregnated DDT dust was used and from fair to poor control was obtained. In one test on Thomas Laxton broadcast peas four different dusts were applied in unreplicated blocks. Three of the dusts were applied early in the morning of May 9, before the dew was off of the plants and when the wind velocity was almost zero. These three dusts were applied to 2 acre plats. The fourth dust, a 1 per cent impregnated DDT, was applied from 10:00 to 12:00 AM after the dew had left the plants and also after the wind had come up to about 5 miles per hour. This fourth treatment was put on the rest of the field which was about 40 acres. Aphid population records were taken by counting the number of aphids in 20 sweeps of an insect net in each treated block at the time of treatment and then again 6 days later. The materials used and the results obtained are given in table 3. These records show the two, 1 per cent DDD plus 2 per cent *Lethane* mixtures, to be about equally effective with 85 and 87 per cent control, while the benzene hexachloride (0.6 per cent gamma) gave 98.5 per cent control. The 1 per cent DDT impregnated dust which was applied under somewhat different conditions gave very poor control. At harvest time the benzene hexa-

[1] These analyses were made through the courtesy of Dr. H. L. Haller and Mr. W. H. White of the U.S.D.A., Bur. Ent. & Pl. Quar., Washington, D. C.

Table 3.—Results of airplane dusting of peas for the control of pea aphids on the Dulaney Freeze Co. farm, May 9, 1946.

Formulation No.[1]	Materials Used (All Applied at 50 Lbs. per Acre)	No. Aphids per Sweep of a Net (Average of 20 Sweeps)		
		May 9	May 15	Per Cent Reduction
7	1% DDT Impregnated plus 2% *Lethane A-70*[2]	642	95	85
7	1% DDT Impregnated plus 2% *Lethane A-70*[2]	692	86	87
18	{Benzene hexachloride (0.6% gamma)	872	13	99
6	1% DDT Impregnated	1184	930	21

[1] Formulation No. for convenience in finding in the text a more detailed description of the materials used.
[2] Prepared by Rohm & Haas Co.
[3] Prepared by Southern States Coop.

chloride treated area showed new and vigorous vine growth and very little aphid damage. The DDT-*Lethane* plats showed some aphid injury. The aphid injury in the DDT treated area was very irregular, ranging from severe to light.

One canning company treated several hundred acres of peas with a 1 per cent DDT impregnated dust applied at the rate of 40 to 50 pounds per acre from an airplane. Treatment was made under ideal weather conditions and good commercial aphid control was obtained.

Several other pea growers on the eastern shore of Virginia and on the mainland reported good control of aphids with a 1 per cent impregnated DDT dust. In general reports on applications from ground machines were better than those from airplane.

SUMMARY.—In these tests benzene hexachloride dusts containing from 0.6 to 0.9 per cent gamma isomer gave excellent pea aphid control. The benzene hexachloride dusts were followed closely in effectiveness by 1 per cent DDT impregnated dusts made with a non-volatile solvent, 1 per cent DDT dust plus an oil, and DDT-oil emulsion sprays which gave good aphid control. Five per cent DDT atomized oil, and the 5 per cent DDT liquefied gas aerosol treatments gave fair to good control. In general the rotenone-bearing dusts and sprays were found to be significantly less effective than the better DDT treatments. One per cent DDT regular mixed dusts, 1 per cent DDT impregnated dusts made with a volatile solvent, and DDT wettable powder sprays gave poor control. The effectiveness of DDT and rotenone-bearing materials were not materially increased by the addition of *Lethane*. The addition of nicotine did not increase the effectiveness of the benzene hexachloride dusts. Airplane application of benzene hexachloride and DDT dusts gave good commercial control when applied under ideal weather conditions.[1]—11-21-46

[1] The authors wish to acknowledge the most able assistance of the following in executing these tests. Dr. E. H. Glass (American Cyanamid & Chemical Corp.), Mr. G. F. Turnipseed and Mr. Tidwell (Shell Oil Co.), Dr. H. G. Walker (Pennsylvania Salt Manufacturing Co.), Mr. F. W. Wilder and Mr. R. H. Israel (Virginia Smelting Co.), and Dr. F. F. Smith and Dr. R. A. Fulton (U.S.D.A. Bur. Ent. & Pl. Quar.). For furnishing fields and materials Mr. Geo. Lippincott (Dulaney Frosted Food Co.), and Mr. A. T. Leatherbury and Mr. Mapp (Eastern Shore Canning Co.).

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The Effect of Particle Size on the Toxicity of DDT Diluents in Water Suspension[1,2]

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The effect of particle size on toxicity of insecticides applied as solids is well known. After a review of the literature, Smith & Goodhue (1942) stated that, "with solid insecticides, particle size determines how well they suspend when made into sprays, how well they distribute when applied as dusts, and how well they adhere to the plant or animal to which they are applied."

McGovran (1940), in tests with Paris green, discovered that particles with a diameter of less than 1.1 microns caused greater mortality to Mexican bean beetles than particles which ranged from 12 to 22 microns in size. Particle size, he said, influenced coverage, the smaller the particles, the better the coverage.

Smith (1936), in tests with pyrethrum powder, reduced particle size by different periods of grinding and found that the finer the powder, the more toxic it was to mosquito larvae, and the more rapid the paralysis. A fine powder covered more surface and exposed more area for a quick kill of insects.

Steiner *et al.* (1944) tested DDT suspensions of different particle sizes produced by different times of grinding with water in a ball mill. In general reducing the mean surface particle diameter increased the toxicity of unweathered DDT deposits. However, the tenacity of the deposits was reduced as the particle size was decreased. The mean surface particle diameters varied from 9.2 microns after one hour of grinding to 4.3 microns after 64 hours.

In a study of the effects of diluents and additives on the toxicity of DDT applied in water suspensions, mixtures of diluents and DDT were prepared by grinding in a mortar. Some mixtures would not pass through the atomizer used in the laboratory sprayer. Further processing by ball-milling and by suspension in a Waring blendor reduced clogging of the nozzle and also greatly increased toxicity of DDT residues to houseflies. This suggested a study of the effect of particle size on toxicity and a more detailed investigation was undertaken.

LABORATORY PROCEDURE.—Diluents used were a group of diatomaceous earths prepared by the Johns-Manville Research Laboratory. These same diluents were used by Turner (1946) in a study of diluents for dusts. Samples for laboratory study were prepared in three ways, all 50 per cent mixtures.

1. Ball-milling.
2. Micro-pulverizing through a fine mesh screen.
3. Impregnating by adding benzene solution of DDT to the diluent and drying, followed by micro-pulverizing.

All processing was done at the Johns-Manville Research Laboratory, as well as particle size determinations.

Three samples of 50 per cent DDT were obtained from the Pennsylvania Salt Manufacturing Company. These mixtures were of identical composition but processed in three different ways, producing different particle sizes. One sample was ball-milled, one coarsely micronized and the third was finely micronized.

All samples were suspended in water in a dosage series of concentrations of 0.5, 0.25, 0.125, 0.0625 and 0.0312 per cent DDT. All samples were sprayed on glass lantern slides for 10 seconds in a precision sprayer designed after the apparatus of Hoskins as described by Richardson (Campbell & Moulton (1943)). Sprayed glass surfaces were dried in a desiccator 24 hours, then exposed to houseflies, *Musca domestica* L., in a cage designed by Garman (1943). Between 25 and 30 five-day old flies, reared according to the Peet-Grady method, were used for each test cage. An exposure of 2 hours was used for all tests, and flies were attracted to the treated surfaces by light. After exposure, flies were fed a solution of honey and water and mortality counts were made 24 hours later. For each sprayed slide two exposures were made and final per cent mortalities are an average of four tests.

FIELD PROCEDURE.—Micro-pulverized mixtures of diatomaceous earth diluents

[1] Eastern Branch Program.

[2] These investigations were supported in part by a research fellowship of the Johns-Manville Corporation through the Crop Protection Institute.

with DDT were prepared in the same manner as laboratory preparations. Field testing of these mixtures in water suspension was carried out on Green Mountain potatoes. Potatoes were planted in 15-foot plots, three rows in width with three replicates for each treatment. Plots were randomized in blocks.

All mixtures were applied at the rate of 2, 1, 0.5 and 0.25 pounds per 100 gallons of water. A power sprayer with a six-row boom, spraying three rows at a time, was used, carrying three nozzles for each row. The spraying pressure averaged 400 pounds and delivery rate was 200 gallons per acre at a 2 mile-per-hour ground speed. The center row nozzles were equipped with quick-acting valves which shut off completely at the end of each plot to prevent drizzling in other treatments. All data and yields were taken from center rows.

Six spray applications were made on the following dates: June 4, 11 and 25, July 9, 16 and 30. The first two sprays were for flea beetles alone and a reading of flea beetle damage was taken on June 19. The third spray was for leafhoppers alone, and the last three for both flea beetles and leafhoppers. Estimates of amount of tip burn were taken on July 17 and second generation flea beetle damage was read on July 25. Insect damage was estimated using a scoring system described by Horsfall (1945).

The three *Penco* samples for field study were not received until mid-season, therefore they are treated as a separate test. These materials were sprayed in a separate block with but one replicate. Only two spray applications were made, on July 16 and 30. Readings were taken of second generation flea beetles only.

To combat late blight which appeared August 14, five applications of fungicide were made on August 16, 20, 24, 30 and September 5. All field data except yield were taken before the onset of blight. Since all plots were treated alike for blight, yield should not be affected by the treatment.

LABORATORY RESULTS.—Mixtures of DDT with diatomaceous earths were tested on houseflies as described above. Deposits of spray residue were weighed for all tests, but since particle size did not affect deposit they are not recorded here.

The results have been summarized in table 1, and table 2 gives data on the particle size range and average size of particles. It will be noted that at almost every concentration reduction in particle size produced greater toxicity. The data for two materials have been plotted in figure 1. Interpolation from the curves shows the dosage required for 85 per cent control of flies was as follows:

SAMPLE	PARTICLE SIZE, MICRONS		PER CENT DDT
	Range	Av. Size	
67 Ball Mill	3 to 75	15 to 25	.42
Micro-Pulverized	3 to 75	10 to 20	.17
Impregnated	2 to 45	10 to 20	.1
69 Ball Mill	2 to 162	20 to 30	.23
Micro-Pulverized	2 to 55	10 to 20	.09
Impregnated	3 to 45	5 to 15	.056

It must be pointed out, however, that between diluents where particle size is the same, there are differences in toxicity but these differences are much less than those between different particle sizes with the same diluent. The fact that the toxicity with different diluents differs, shows that there are factors other than particle size affecting the toxicity of DDT and diluents in water suspension.

Table 3 shows the particle size and per cent mortality for the three Penco samples of identical composition but different particle sizes. Within the three samples there are marked differences in particle size affecting toxicity. The fine micronized sample with the smallest particle size is the most toxic while the intermediate or coarse micronized sample is better than the ball-milled high particle size sample.

FIELD RESULTS.—Two of the best diluents tested in the laboratory, 67 and 69, were taken to the field for tests on potatoes. Results of insect control and yield by weight in pounds are recorded in table 4 and figures 2 and 3. Particle sizes for these field samples appear in table 5.

It will be noted that the impregnated samples used in the field tests did not have a smaller particle size than the plain micro-pulverized samples, as was the case with the laboratory samples. When the field samples were prepared, excessive heating of the pulverizer made it necessary to grind the impregnated samples

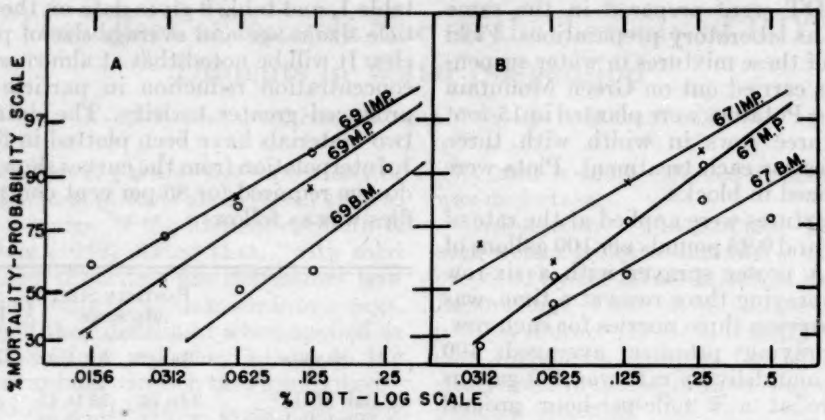

FIG. 1.—Toxicity of residues of DDT to houseflies in the laboratory as affected by particle sizes resulting from three methods of processing. B.M.=ball-milled; M.P.=micro-pulverized and I.M.P.=impregnated and micro-pulverized.

Table 1.—Laboratory tests of ball-milled and micro-pulverized samples of DDT diluents in water suspension.[1]

Sample	Per Cent DDT	Per Cent Kill Test 1	Test 2	Av. (4 Tests)
52	.0625	13.5	58.0	35.7
Ball Mill	.125	33.8	55.1	44.4
	.25	33.5	79.9	56.7
	.5	50.3	86.6	68.2
52	.0312		32.1	32.1
Micro-Pulv.	.0625	19.2	83.3	51.2
	.125	41.0	79.1	60.0
	.25	100	100	100
	.5	100		100
54	.0625	49.6	41.9	45.7
Ball Mill	.125	43.1	72.7	57.9
	.25	49.9	93.5	71.7
	.5	90.0	100	95.0
54	.0312		72.6	72.5
Micro-Pulv.	.0625	67.3	86.2	76.7
	.125	92.8	100	96.4
	.25	96.8	100	98.4
	.5	95.4		95.4
55	.0625	39.7	74.1	56.9
Ball Mill	.125	52.5	68.9	60.7
	.25	33.6	100	66.8
	.5		100	100
55	.0312		73.7	73.7
Imp. Micro	.0625	69.4	81.0	75.2
Pulv.	.125	83.8	100	91.9
	.25	100	100	100
	.5	100		100
64	.0625		65.7	65.7
Ball Mill	.125	73.8	70.4	72.1
	.25	75.7	85.7	80.7
	.5	100	86.5	93.2

Table 1. Continued—Laboratory tests of ball-milled and micro-pulverized samples of DDT diluents in water suspension.[1]

Sample	Per Cent DDT	Per Cent Kill Test 1	Test 2	Test 3	Average
64	.0312			80.0	80.0
Micro-Pulv.	.0625	78.5		86.8	82.6
	.125	90.3		90.6	90.4
	.25	86.6		93.7	90.1
	.5	98.1			98.1
67	.0625	14.3	73.4		43.8
Ball Mill	.125	28.6	84.3		56.4
	.25	70.9	97.7		84.3
67	.0312	26.0			26.0
Micro-Pulv.	.0625	38.0	55.6	93.0	56.1
	.125	76.5	57.5	100	77.6
	.25	83.4	100	100	91.7
67	.0312	52.8		86.6	69.7
Imp. Micro-	.0625	41.9	63.1	97.3	61.0
Pulv.	.125	77.1	98.0	100	88.0
	.25	87.8	100	100	93.9
69	.0625	30.1	71.1		50.6
Ball Mill	.125	73.0	42.6		57.8
	.25	94.7	86.8		90.7
69	.0156			24.5	24.5
Micro-Pulv.	.0312	43.0		18.8	30.9
	.0625	44.1	63.9	59.0	52.7
	.125	85.1	95.6	78.0	85.9
	.25	74.4	100		87.2
69	.0156			47.1	47.1
Imp. Micro-	.0312	51.1		91.1	61.3
Pulv.	.0625	53.2	76.2	66.9	72.1
	.125	70.0	100	90.9	82.7
	.25	87.5	100	100	93.7

[1] Each test is the average per cent kill of two tests on the same sprayed surface.

Table 2.—Particle size and per cent DDT required to kill 85 per cent of the flies.

Sample	Particle Size, Microns	
	Range	Average Size
52 Ball Mill	2–75	20–30
Micro-Pulv.	2–50	10–20
54 Ball Mill	2–75	20–30
Micro-Pulv.	2–90	10–20
55 Ball Mill Imp.	2–50	10–20
64 Ball Mill	2–90	20–30
Micro-Pulv.	2–75	15–25
67 Ball Mill	3–75	15–25
Micro-Pulv.	3–75	10–20
Imp.	2–45	10–20
69 Ball Mill	2–162	20–30
Micro-Pulv.	2–55	10–20
Imp.	3–45	5–15

only once, while the plain mixtures were ground twice.

It will be noted in table 4 that the control of second-generation flea beetles and tip burn was predominantly in accordance with particle size of the DDT. Results for control of the first generation of flea beetles were variable. Damage was very low, only 12 per cent of the foliage was destroyed on unsprayed plants. The best treatment had only 2.8 per cent and the poorest only 6 per cent damage. It is obviously difficult to separate the effects of treatment within such a small range of damage. Since the damage to untreated plants in the second generation estimates was 61 per cent and the range between the best and poorest treatments 1.8 per cent and 7.5 per cent, more reliance can be placed on the results for the second generation.

The dosage required for equal control has been interpolated from the curves in figure 2 and given in table 5. It is evident that there were much greater differences between the samples with diluent 67 than with sample 69. This is to be expected because there is a difference in average particle size as well as range in sample 67.

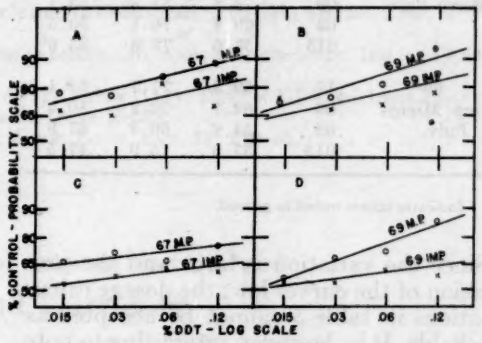

FIG. 2.—Toxicity of DDT water suspensions to potato insects as affected by particle sizes resulting from two methods of processing. A and B, materials with two diluents used against the summer generation of the potato flea beetle; B and C the same materials used for control of tip burn produced by leafhoppers. M.P. = micro-pulverized; I.M.P. = impregnated and micro-pulverized.

Table 3.—Laboratory assay of three *Penco* samples.

Sample	Per Cent DDT	Particle Size, Microns		Per Cent Kill		
		Range	Av. Size	Test 1	Test 2	Average (4 Tests)
Penco	.0625	2–100	25–35	89.7	59.5	74.8
Ball Mill	.125			100	31.9	65.9
	.25			88.4	77.8	83.1
	.5			100	96.1	98.0
Penco	.0312	2–40	15–25	47.8	50.0	48.9
Coarse	.0625			85.1	84.7	84.9
Micronized	.125			96.6	88.2	92.4
	.25			100	100	100
Penco	.0156	2–30	10–20	86.0	49.7	67.9
Fine	.0312			87.5	51.6	69.5
Micronized	.0625			100	37.6	68.8
	.125			100	100	100

Table 4.—Results of field tests of DDT diluents.

Sample	Per Cent DDT	Per Cent Control: Flea Beetle 2nd Gen.	Per Cent Control: Tip Burn	Yield in Lbs.
67 Micro-Pulv.	.12	76.2	88.8	44.4[1]
	.06	67.7	83.6	50.4
	.03	72.8	76.9	54.7
	.015	67.7	77.7	41.5
67 Imp. Micro-Pulv.	.12	61.0	72.2	51.9
	.06	64.4	81.6	37.7[1]
	.03	59.3	66.6	29.4
	.015	54.2	69.4	50.4
69 Micro-Pulv.	.12	86.4	92.7	26.1[1]
	.06	72.8	81.6	53.1
	.03	69.4	76.1	50.5
	.015	57.6	73.3	33.6[1]
69 Imp. Micro-Pulv.	.12	59.3	77.7	51.1
	.06	62.7	72.2	40.6[1]
	.03	54.2	69.4	47.8
	.015	57.6	75.0	47.5

[1] Indicates tubers rotted in ground.

Since the variation is large and the precision of the curves low, the dosage calculations in table 5 cannot be accepted as reliable. It is, however, interesting to note that the differences are larger in reference to particle size than in the laboratory tests. Moreover, the differences are substantial and merit consideration in further tests.

The two applications of *Penco* materials (Table 6, Fig. 4) likewise showed substantial differences in control directly in accordance with particle size. No comparison can be made with the material in table 4, because of the difference in schedule of treatment.

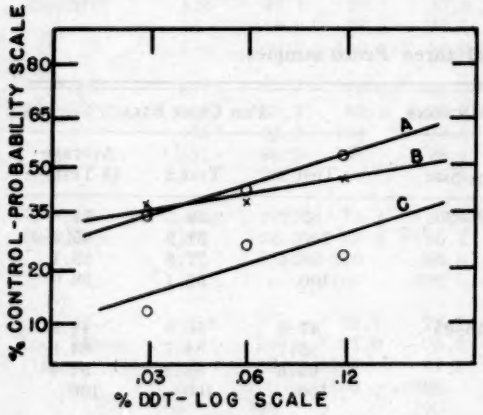

FIG. 3.—Toxicity of materials of three particle sizes prepared by different methods of processing to the summer generation of the potato flea beetle. A = finely micronized, B = coarsely micronized and C = ball-milled.

Potatoes were dug early in October and yield is summarized in table 4. In addition to the variations caused by soil heterogeneity, tuber rot was serious in several plots in low portions of the field. It is therefore difficult to estimate the effect of particle size of the DDT on yield with any accuracy. However, if the plots in which rot was serious are ignored, smaller particle size produced greater yield with only one exception. This was in the case of the coarsely micronized Penco which yielded less than the ball-milled sample. Furthermore, the differences appear to be of a magnitude of practical importance (10 to 15 per cent between size ranges of 5–10 microns).

DISCUSSION OF RESULTS.—In addition to producing more particles per unit of weight, reduction of particle size may also affect (1) the shape of particles and (2) their tenacity. If the shape is unchanged, the toxicity may be increased but the slopes of the dosage-response curves should not be affected (Horsfall 1945). In both laboratory and field tests, the toxicity of DDT in water suspensions was increased by smaller particle size. In general, there was no pattern of increased slope to indicate improved coverage although in one field test, the control of second generation flea beetles, the slope of "69 impregnated" changed. No explanation can be offered for this change in slope although it does not seem to be directly associated with particle size. Impregnation might change the shape of DDT particles, which would produce a change in slope, but we have no evidence that this has occurred. According to Horsfall (1945) reduction of particle size may cause an increase in tenacity, which also should not affect the slope.

It seems startling at first glance, that the toxicity of DDT residues in the field against two potato insects can be predicted from assay in the laboratory against the housefly. However, this seems to be the case within diluents. Between diluents, of course, this is not true, because of the effect of diluents on tenacity which has not been discussed here.

SUMMARY.—Laboratory assay of DDT residues in water suspension showed that reduction of DDT particle size would cause an increase in toxicity of the residues to houseflies.

When tested in the field on potato insects, the same DDT-diluents confirmed laboratory results. They performed according to their particle size, highest control and heaviest yields resulting from those residues with the smallest particle size.

Since there is such a high degree of correlation between field and laboratory tests, it appears that the laboratory method may be used with confidence in determining many phases of the toxicity of DDT formulations.—11-19-47.

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A Classification of Insecticide Dust Diluents and Carriers[1,2]

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An investigation of physical and chemical properties and inherent toxicities of the materials used as diluents and carriers in insecticidal dusts was recently initiated at Cornell University. In the assembling of data on the 75-odd commercially available materials it was found desirable to work out a system of classification to aid in cataloging and to give an over-all picture of the relationships existing between materials which were apparently very different. It is hoped that the classification which has evolved from the studies may prove as useful to others interested in the field as it has to the authors.

There are, as indicated in table 1, two major headings under which all of the diluents and carriers so far encountered can be placed. Among the *Botanical Flours* can be included all those materials which are directly of plant origin, most of them being merely dried and ground plants or plant parts which have been processed primarily for other uses. As a general rule these flours are used as carriers for absorbing or adsorbing liquid insecticides and require additional quantities of diluents to meet the physical requirements of dusting machinery. Because of the restricted use and the diverse nature of these materials, it appears sufficient at present merely to list them in alphabetical order without subclassification.

The vast majority of the diluents in use today fall in the category here called *Minerals*. For the major groupings of these materials the authors have mainly followed Dana (1932). Dana's classification has been modified somewhat; first, by some simplification because of the relatively few classes of minerals containing members used as diluents; second, by the use of more recent information, particularly on the clay minerals; and third, by the inclusion of artificially produced materials among the true minerals of similar

[1] Eastern Branch Program.

[2] For very valuable information and advice, the authors wish to express their appreciation to Professors V. D. Frechette and J. F. McMahon of the New York State College of Ceramics at Alfred University; to Professor J. D. Burfoot of the Geology Department at Cornell University; and to the many diluent companies which have supplied data on their respective materials.

chemical composition and physical properties. The inclusion of manufactured materials among the true minerals rather than in a separate category was considered desirable because the chemical and physical properties determine the usefulness of materials as diluents or carriers, and the origins as such are of little importance.

It is frequently found that a material used as a diluent may be a mixture of minerals; in fact, this is usually the case. In mineralogical literature there are suggestions that a material be classed with a specific group if it is composed of more than 50 per cent of the mineral characteristic of that group, and in some cases the suggested minimum content is even higher. It is suggested here that for insecticidal purposes a mixture of minerals be classed with the mineral occurring in highest percentage. This criterion will usually give a clear distinction as in most instances one mineral definitely predominates and is responsible for most of the properties of the mixture.

Of the seven major groups of minerals comprising dust diluents, two, the *Oxides* and the *Silicates*, embrace the vast majority. Representatives of the five others are relatively few in number and, in general, have found rather limited use. Sulfur is the only one of the elements used to any extent as a diluent, and its selection is based not only on the dusting and other physical properties which it imparts to a mixture, but frequently on its possible usefulness as an active ingredient. Apparently the only one of the *Carbonates* used at present is calcium carbonate which is classified as calcite in the present scheme whether natural or synthetic. Use of this material has been rather restricted, chiefly because of its relatively high bulk density. Among the *Sulfates* gypsum, $CaSo_4 \cdot 2H_2O$, seems to be the only mineral in use as a diluent. It is chemically inert and neutral but, like calcite, it has a high bulk density. Among the *Phosphates*, the single representative found is a synthetic material having the same empirical formula, $3Ca_3(PO_4)_2 \cdot Ca(OH)_2$, as the variety of apatite called hydroxyapatite.

Special mention must be made of the group which the authors have chosen to call *Indeterminate* because it includes those materials which, despite their inorganic origins, reveal no definite mineral patterns. Quite frequently the glassy rocks, of which pumice is an example, are discussed in textbooks of mineralogy but they are not considered as minerals because, as Dana describes them, they are volcanic rocks which "have cooled so rapidly that they are wholly or in part made up of glassy material in which the different elements have not had the necessary opportunity to group themselves into definite minerals." At present, there are only three pumice diluents on the market and two of these are produced by one company as apparently two different grades of the same material.

The second largest group of minerals used in the diluent industry is that of the *Oxides*, of which silicon dioxide is the chief example. Two minerals belonging to the quartz family, tripolite and diatomite, have been used extensively. These are

Table 1.—Classification of insecticide dust diluents and carriers.

- Botanical Flours
  - Soybean flour
  - Tobacco flour
  - Walnut shell flour
  - Wheat flour
  - Wood flour
- Minerals
  - Elements
    - Sulfur
  - Oxides
    - Silicon
      - Tripolite
      - Diatomite
    - Calcium
      - Calcium lime
      - Magnesium lime
  - Carbonates
    - Calcite
    - Dolomite
  - Sulfates
    - Gypsum
  - Silicates
    - Mica
    - Talc
    - Pyrophyllite
    - Clays
      - Montmorillonite group
        - Montmorillonite
        - Saponite
        - Nontronite
        - Beidellite
      - Kaolinite group
        - Kaolinite
        - Nacrite
        - Dickite
        - Anauxite
      - Attapulgite group
        - Attapulgite
        - Sepiolite
  - Phosphates
    - Apatite
  - Indeterminate
    - Pumice

listed by Dana as synonymous, but a differentiation seems highly desirable in their classification as diluents because of great differences in physical properties. The authors have chosen the classification of Dake *et al.* (1938), in which both are included in the quartz family and are differentiated on the basis of origin, diatomite being a residue from living organisms and tripolite being derived by inorganic processes from other silica-containing deposits. The various grades of tripoli in use as diluents consist largely of the mineral tripolite and the diatomaceous earths of diatomite.

The calcium oxides are not naturally-occurring minerals, being produced by heat treatment of the calcites and dolomites. As is common practice, they are classed as oxides whether in the oxide form as quicklime or in the hydroxide form as hydrated lime. Various classifications of limes on the basis of CaO and MgO content have been proposed, of which one of the most complete and widely used is that of Lazell (1915) who divided them into five groups. For insecticidal dust purposes, it appears sufficient to class them as calcium limes when they contain less than 10 per cent MgO, and magnesium limes when they contain 10 per cent or more. Few limes used with insecticides fall close to this dividing line, those derived from calcite usually being lower than 10 per cent in MgO content, and those from dolomite higher.

By far the largest group of minerals to be found among the diluents is the *Silicates*, in which the structural unit is considered to be a tetrahedron of four oxygen atoms surrounding each silicon atom. The type of silicate mineral depends upon the arrangement of the tetrahedra, the substitution of Al or Mg for part of the Si, and the presence of other structural units containing Al, Mg, Ca, Fe, Na, K, etc. For full discussions of this subject, the reader is referred to Dana (1932) and to Swartz (1937). Those silicates used as diluents can be included in four groups: the micas, talcs, pyrophyllites, and clays. So far only one member of Dana's mica division seems to be used commercially and it apparently belongs to the chlorite group.

Approximately a third of the diluents on the commercial market are talcs. Talc is essentially an hydrous metasilicate of magnesium, $H_2O \cdot 3MgO \cdot 4SiO_2$, which always has the same basic structure but may occur in grossly different forms. The three forms used as diluents are the fibrous or spicular, foliated or flat, and massive or granular (such as soapstone or steatite), although many other terms are employed in the literature in describing these and other variations. The variation in form is sometimes due to the fact that the talc is derived from another mineral by gradual alteration, and the outer form of the parent mineral may be retained. Frequently the alteration is not complete and the talc is therefore mixed with considerable amounts of other minerals. Likewise, it must be borne in mind that the diluent business has developed quite largely as a means of using grades of minerals unsuitable for industries such as paint, rubber, cosmetics, and ceramics. Quite frequently it seems to be the case that these grades are sorted out and eventually milled together to produce a much cheaper insecticide grade. Hence, mixtures are more likely to occur in this grade of material than in any other, but the type of diluent produced from any one deposit is likely to run true.

In recent years the mineral pyrophyllite has come to the fore as a diluent. It is an interesting material in that it somewhat bridges the gap between clays and talcs. It is chemically an hydrous aluminum silicate, $H_2O \cdot Al_2O_3 \cdot 4SiO_2$, and is therefore closely related to the clays in this regard. Physically, however, it is more like talc. There are several varieties of the mineral as is true of talc, but the kind most frequently used in insecticides is one in which the particles are flat or plate-like.

Over 30 different clays used in insecticidal dust mixtures have come to the attention of the authors and there are probably many more which are used locally near mines operating for other purposes. It is very difficult to locate a satisfactory definition of the term "clay," but an excellent summary on this subject, as well as on the clay minerals, has been given by Grim (1942). According to this author the term "clay" carries three implications: "(1) a natural material with plastic properties; (2) an essential composition of particles of very fine size grades; and (3) an essential composition of crystalline fragments of minerals that are essentially hydrous aluminum silicates or occasionally hydrous magnesium silicates." It is sug-

gested here that Grim's division of the clay minerals into groups be adopted although only three of them contain minerals found in major proportions in clays used at present as insecticide diluents. These are the montmorillonite group, the kaolinite group, and the attapulgite group bearing respectively the names of their chief members.

In the montmorillonite group occur the minerals montmorillonite, saponite, nontronite, and beidellite, all of which have expanding lattice structures. Montmorillonite, $(OH)_4Al_4Si_8O_{20} \cdot xH_2O$, is the chief constituent of our so-called bentonites, and for our purposes this entire group might be called the bentonite group. From there one might consider as bentonites those clays composed largely of montmorillonite or beidellite and which swell on wetting with water, and as metabentonites or sub-bentonites those which do not swell on wetting. These groups would, in part, correspond to the alkali bentonites and alkali-earth bentonites advanced by Davis (1940) and his associates. While it does not appear necessary to extend the entomological classification of diluents very far into the special field of bentonites because of their rather restricted uses in dusts, still it does seem wise that wherever a bentonite is used it at least be designated as swelling or non-swelling.

The majority of clays used as dust diluents fall in the kaolinite group which contains the minerals kaolinite, nacrite, dickite, and anauxite, with kaolinite being the most common in occurrence. The various china clays and kaolin clays are composed quite largely of kaolinite. They do not have an expanding lattice structure and in particle shape they may vary somewhat between grains and plates when viewed under the microscope, but they are never spicular or fibrous in form. Grim gives the composition of kaolinite as $(OH)_8Al_4Si_4O_{10}$.

The last group of clay minerals represented in the field under discussion is that of the attapulgite group with the mineral attapulgite itself having, according to Grim, a composition of $(OH_2)_4(OH)_2$-$Mg_5Si_8O_{20} \cdot 4H_2O$. Caldwell & Marshall (1942) state that the individual particles of the sample of attapulgite with which they worked appeared fibrous in crystal habit, and later that this is the first clay mineral found to have other than a micaceous structure. So far only two commercially available diluents composed of this mineral seem to be in use and in both of these the particle shape is also spicular or fibrous.

SUMMARY.—As a common basis for future work and discussions on the diluents and carriers used in insecticidal dusts, a classification of these materials is presented. It is based primarily upon the mineralogical content of the materials as given by various mineralogists, but modifications of their systems are suggested in order to provide for the few materials which fall outside the category of bodies produced by inorganic nature. Two principal groups of materials are set up as botanical flours, and minerals both synthetic and natural. The vast majority of the commonly used diluents fall in the category of minerals which are divided into the elements, oxides, carbonates, sulfates, silicates, phosphates, and an indeterminate group.—11-26-46.

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Toxicity of Insecticide Dust Diluents and Carriers to Larvae of the Mexican Bean Beetle[1,2]

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In order to interpret toxicological results clearly, it becomes necessary to evaluate all the factors that may influence the toxicity of the insecticide under consideration. Considerable study has been given to the effect of the dust diluent or carrier on the toxicities of dust mixtures, with special emphasis on the physical and chemical properties of the diluent. A factor often overlooked is the toxicity of the diluent itself.

Huckett (1929), in evaluating dust mixtures for the control of cucumber beetles, found that moderate to heavy doses of lime gave up to 100 per cent kill of the beetles exposed to the dust. This mortality was greatly affected by humidity, a low humidity series giving 100 per cent kill in 24 hours and a high humidity series only 6.3 per cent. Driggers (1929) found that newly emerged larvae of the oriental fruit moth and the codling moth were very susceptible to talc, lime and mica. Zacher (1930) classified oxides and carbonates of magnesium, manganese and silicon as true contact insecticides in their action on species of *Periplaneta*, *Calendra*, and *Phyllotreta*. He believed the action of these materials to be of such a nature as to cause death by desiccation. Richardson (1932) also found the 12-spotted cucumber beetle susceptible to "inert" materials and showed that large quantities of gypsum, kaolin, and bentonite passed into the posterior half of the digestive tract. Boyce (1932) found a similar condition in the walnut husk fly when dealing with the toxicity of talcs, diatomaceous earths, etc. He found that bentonite caused a plugging of the hind gut. Laboratory studies indicated that most diluents were toxic and that diatomaceous earth was the most toxic of the materials tested. Dietz (1934), working with blister beetles, found that kaolin gave a 70 per cent kill as compared to 100 per cent kill with barium silicofluoride. Briscoe (1943), studying the action of inorganic dusts on insects, found that no chemical reactions were involved in the toxicity but that the action was due to a physical process. He found a correlation between hardness of material and effectiveness in producing kill. Wigglesworth (1945) made an extensive study of the action of inorganic materials on insect cuticle. He demonstrated abrasion of the water-retaining epicuticle and subsequent desiccation of *Rhodnius*. Live *Rhodnius*, when dusted with alumina and held at 30° C. and reduced humidity, lost up to 46.5 per cent of their body weight in 24 hours. When suspended in air to prevent crawling, however, they lost no weight after being dusted with alumina. When *Rhodnius* was abraded with alumina and exposed to 2 per cent nicotine, complete collapse of the insect followed in 20 minutes, whereas unabraded insects were only slightly affected in 24 hours. When dry powdered rotenone was used, unabraded insects were unaffected after 3 weeks whereas abraded insects were dead within 24 hours. Thus it was demonstrated that abrasiveness of a diluent used in a dust mixture may be a determining factor in the penetration of the toxicant through the body wall.

The toxicity of so-called "inert materials" to larvae of the Mexican bean beetle soon became apparent during a preliminary investigation on the effects of climatic factors on the action of mixed dusts. It was then decided to investigate more fully the extent of this toxicity. The investigations were begun as (1) a study of the effect of larval age on susceptibility to dusts, (2) a toxicological survey of all the available commercial diluents, (3) a determination of the effects of temperature, humidity, and light on the action of the diluents, and (4) an evaluation of the effects of diluents on the toxicities of mixed dusts. A summary of the results from parts 1, 2, and 4 is herein reported.

MATERIALS AND METHODS.—The diluents used were samples obtained from commercial outlets and received no further treatment such as grinding, etc., before being used. In all cases they were applied as dusts by one of two methods.

[1] The data contained herein are a portion of the results of research to be presented in the doctor's dissertation for partial fulfillment of the requirements for the Ph.D. degree in Entomology at Cornell University.

[2] Eastern Branch Program.

Where precision deposits were not required the dusts were applied with a salt-shaker type of applicator consisting of a small specimen vial covered with muslin. By inverting this vial and tapping it gently a fairly uniform deposit could be obtained. Where precision deposits were necessary, a laboratory dust settling tower was used.

Tests were made in glass specimen dishes 112 mm. wide by 50 mm. deep. A layer of paper toweling was placed on the bottom of each dish and on this was pressed a bean leaf which adhered to the toweling and prevented the larvae from feeding on the underside of the leaf. The exposed surface of leaf and paper toweling was dusted and 10 undusted larvae were placed in each dish to feed. A thin layer of vaseline was smeared on the inside edge of the dish to prevent escape of the larvae. Mortality counts were then made at desired intervals. In the first two series of experiments the tests were conducted under room temperatures but in the studies of mixed dusts they were run in a controlled climate cabinet. In this cabinet the temperature variation was about $\pm 1°$ F. and the relative humidity variation less than ± 3 per cent.

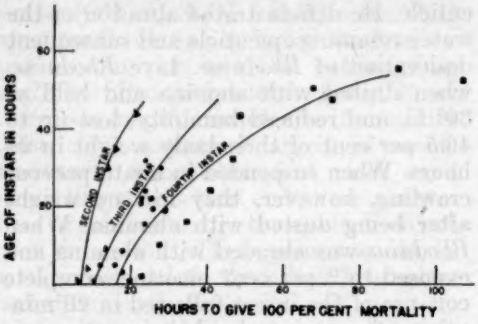

FIG. 1.—Susceptibility of Mexican bean beetle larvae of different ages to *Attaclay* dusted on excised bean leaves.

LARVAL AGE AND SUSCEPTIBILITY.—Variations in susceptibility of test insects in preliminary studies were felt to be primarily caused by age differences among the larvae used, even though they were of the same instar. In addition there were noticeable differences in susceptibility between different instars. To evaluate the influence of age on toxicity, a large enough culture of bean beetles was maintained to make it possible to pick off considerable numbers of freshly molted larvae of any desired instar. These were then placed on a greenhouse saucer of bean seedlings and allowed to reach the desired age for testing. At the desired age they were placed on freshly dusted bean leaves, 10 larvae to a dish, the number of replications depending upon the supply of insects available. *Attaclay* was selected for use in these tests because it had shown considerable toxicity in preliminary studies. Deposits of approximately 0.3 mg. per sq. cm. were employed. Times required to reach 100 per cent mortality in the various age groups are summarized in figure 1.

It is evident that as age of instar increased susceptibility decreased. This was most pronounced in fourth instar larvae in which the time required to give 100 per cent mortality ranged from approximately 18 to 100 hours. Among second instar larvae it ranged only from 6 to 20 hours. In each instar, however, the old larvae were more resistant than newly emerged larvae of the following instar.

INDIVIDUAL DILUENT TOXICITIES.—Sixty-one materials were available at the time these tests were run. Dusts were applied with the salt-shaker type of applicator. Because of the large number of larvae which would have been necessary to run replications on all the diluents simultaneously, the tests were conducted at three different times employing 10 larvae for each diluent on each of the three dates of application. This procedure also served to overcome, at least in part, the effects of different larval ages and different climatic conditions which would have been encountered had each set of tests consisted of all three replicates of only a few diluents. The tests were run under laboratory conditions including a temperature averaging about 75° F. Results of the tests were grouped according to the classification of the materials and are listed in table 1. The per cent mortality figure for each diluent is an average of the kills obtained at 68 hours in the three replicates of 10 larvae each.

An examination of the tabulated results indicates clearly that there were wide variations among the toxicities of materials within certain groups. Thus, the factor determining toxicity did not appear to be chemical but rather of a physical nature. In the case of the talcs, for ex-

ample, the toxicities ranged from zero to 50 per cent, and, in general, the spicular types were the most toxic. The members of the diatomite and attapulgite series were all high in toxicity but in both groups the number of samples available was limited. None of the five botanical flours tested showed any toxicity, and similarly, the three members of the carbonate group were at least very low in toxicity.

DILUENT TOXICITIES IN DUST MIXTURES.—The primary cause of death from the action of an insecticidal dust diluent is generally presumed to be one of desiccation. It is reasonable to assume that high temperature and low humidity would favor this process. Also it would seem logical to assume that the action of the diluent should become negligible under conditions of low temperature and high relative humidity, due to reduced effects of desiccation. It becomes necessary, however, to consider the effects of abrasion on the entrance of the toxicant. In a study of these effects tests were conducted using two diluents; walnut shell flour, which had shown no toxicity in previous tests and could be classed as a non-abrasive diluent, and a kaolinitic clay which had shown a high degree of toxicity and could be classed as a material which might be abrasive to insects. The toxicants used were cryolite, at concentrations of 6.25 and 50 per cent in both diluents, and rotenone at a concentration of 50.75 per cent in both diluents. All mixtures, and also the diluents alone, were tested against 30 fourth instar larvae in three replicates of 10 larvae each. The tests were run at two levels of temperature and relative humidity, 90° F. with 38 per cent R. H., and 75° F. with 75 per cent R. H. In this manner, then, the tests were run at a combination of high temperature and low humidity under which the effects of desiccation should have been pronounced, and also at a lower temperature and high relative humidity under which they should have been reduced. Mortality counts were taken at regular intervals until high percentage kills were obtained. A summary of the data is given in figures 2, 3 and 4. Each point on the graphs represents an average per cent mortality of three replicates at the indicated time interval.

From an examination of the graphs the following observations may be made:

1. The toxicity of each material and mixture was greater under conditions of high temperature and low humidity than under conditions of low temperature and high humidity. The exception was walnut shell flour which, when used alone, showed no toxicity under either set of conditions.

Table 1.—Mortalities of fourth instar Mexican bean beetle larvae on leaves dusted with various diluents and carriers.

CLASSIFICATION	DILUENT	PER CENT MORTALITY
Botanical Flours		
Soybean Flour	*Archer Brand Nutrisoy R*	0.0
	Lo-Fat Soy Flour	0.0
Tobacco Flour	*Filter Dust*	0.0
Walnut Shell Flour	*WF-5 Walnut Shell Flour*	0.0
Wood Flour	*Solka-Fil*	0.0
Minerals		
Elements		
Sulfur	*Sulfur Smoke*	0.0
Oxides		
Silicon		
Tripolite	*Seneca Std. D. G. Rose Tripoli*	3.3
	RD-1 Ground Silica	30.0
Diatomite	*Dicalite IG-5*	70.0
	Celite 209	85.0
	No. 680 Multicel	46.0
Calcium		
Calcium Lime	*Gold Bond Spray Hyd. Lime*	60.0
	Hydrated Lime	30.0
Magnesium Lime	*Milk of Magnesium Lime*	3.3
	Ohio Superspray Hyd. Lime	10.0
Carbonates		
Calcite	*Millical Brand Calcium Carbonate*	0.0
	OHCO Whiting No. 354	10.0
	"98" Pulverized High Calcium Limestone	0.0
Silicates		
Talc	*Asbestine 3X*	60.0
	Asbestine 5X	13.3
	Asbestol Regular	25.0
	No. 2 Talc Dust	0.0
	B. O. Grade Talc	0.0
	EMTCO 23 Talc	0.0
	EMTCO 42 Talc	0.0
	A-White Talc	3.0
	Loomkill Talc	20.0
	Sierra Cloud Talc	0.0
	Sierralite 200	6.0
	Sierralite 325	13.0
	No. 6-J Talc	0.0
	C-2 Talc	0.0
	No. 325-C Talc	13.0
	Blue Talc	10.0
Pyrophyllite	*Insecticide Grade Pyrophyllite*	20.0
	No. 3 Pyrophyllite	20.0
	Airfloat No. 1 Pyrophyllite	6.0
	Py Dust Standard Grade	0.0
	Pyrax B	0.0
Clay		
Montmorillonite	*Panther Creek Bentonite*	0.0
	S. P. Volclay 200 Mesh	13.3
	Filtrol X-415	0.0
	Fullers Earth	63.3
	WB-25 Bentonite (Wyo-Bond)	10.0
Kaolinite	*Barden Clay*	93.3
	Asp No. 100 China Clay,	46.6
	Kaolloid Clay	43.3
	Type 41 Clay	66.7
	Inert "C"	56.6
	Bancroft Clay	43.3
	Sheridan No. 6 Clay	16.6
	Bancroft 15 Clay	16.6
Attapulgite	*Attaclay*	75.5
	Diluex	60.0
Unidentified	*"Sax" Clay*	56.6
	OHCO Powdered Clay No. 156	3.3
	T-7 Clay	53.3
	No. 2 Tammfloss Clay	66.6
	Cherokee Clay	20.0

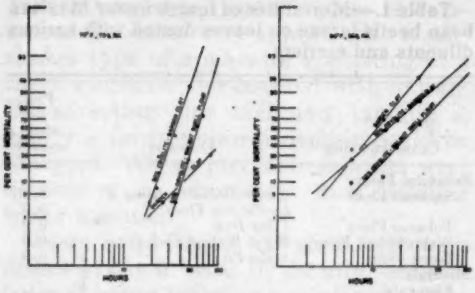

FIG. 2.—Mortalities among fourth instar Mexican bean beetle larvae on bean leaves dusted with each of two diluents alone, and with a mixture of each diluent with cryolite (50-50). Walnut shell flour alone showed no toxicity.

2. Mixtures containing *Barden Clay* as a diluent were more toxic than corresponding ones containing walnut shell flour as a diluent.

3. At high temperature and low relative humidity *Barden Clay* itself exhibited toxicity approaching that of the cryolite or rotenone mixtures in which it was used, and greater toxicity than rotenone or cryolite mixtures containing walnut shell flour.

4. At low temperature and high relative humidity the differences obtained between the clay mixtures and walnut shell flour mixtures were equal to or greater than those obtained at high temperature and low humidity.

5. At low temperature and high relative humidity the toxicity of the *Barden Clay* alone was very low since the time required to give 50 per cent mortality was approximately 120 hours.

6. Walnut shell flour mixtures containing 6.25 per cent cryolite or 0.75 per cent rotenone were non-toxic at low temperature and high relative humidity during the period of observation in these tests.

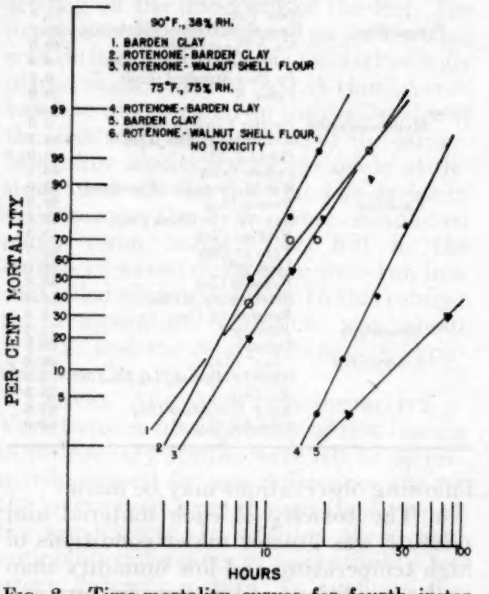

FIG. 3.—Time-mortality curves for fourth instar Mexican bean beetle larvae held on bean leaves dusted with two diluents used alone and with mixtures of each of the diluents with rotenone (0.75%). Walnut shell flour alone showed no toxicity.

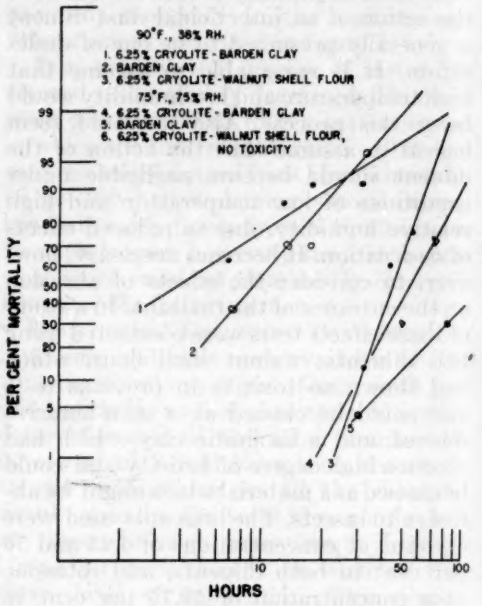

FIG. 4.—Time-mortality curves for fourth instar Mexican bean beetle larvae held on bean leaves dusted with two diluents used alone and with mixtures of each of the diluents with cryolite (6.25%). Walnut shell flour alone showed no toxicity.

It is clear, then, that under conditions of high temperature and low humidity the toxicities of the dusts used in these tests were affected by the toxicities of the diluents. The high toxicity of *Barden Clay* used alone where desiccation might be expected suggests that the effect of this material in increasing the toxicity of the mixtures under high temperatures and low relative humidities might be due chiefly to desiccation.

At low temperatures and high relative humidities, under which desiccation should not be pronounced, *Barden Clay* alone, as might be expected, showed little toxicity. However, mixtures containing this material as a diluent were again more

toxic than those containing walnut shell flour as a diluent. These differences cannot logically be explained on the basis of desiccation alone. A more likely basis might be found in the suggestion of Wigglesworth (1945) to the effect that abrasion of the insect cuticle permits more rapid penetration of the toxicant into the insect. In this case the penetration into the body cavity might conceivably be either through the body wall or through the gut wall.

Thus it appears that the effect of a diluent on the toxicity of a dust mixture may arise from at least two factors. If abrasion is the primary action of a diluent in affecting toxicity, then there may be at least two secondary modes of action, desiccation and increased penetration of the toxicant. The relative importance of these two modes of action apparently depends upon climatic conditions. Under conditions favorable for desiccation this effect may overshadow that of increased penetration of the toxicant, while under conditions unfavorable for desiccation, increased penetration of the toxicant may be the more important.

SUMMARY.—Groups of Mexican bean beetle larvae of various ages were held on excised bean leaves dusted with *Attaclay* until 100 per cent mortalities were obtained. As age of instar increased susceptibility decreased, and the old individuals in each instar were more resistant than newly emerged larvae of the following instar.

Sixty-one commercially available diluents and carriers were tested as to toxicity to fourth instar Mexican bean beetle larvae. Wide variations among the toxicities of materials within some groups indicated that the factor determining toxicity was of a physical rather than a chemical nature. Nevertheless, members of certain other groups were consistently high or low in toxicity.

From a study of two diluents used in finished dusts containing cryolite or rotenone it seemed logical to conclude that the effect of a diluent on the toxicity of a mixture may arise from two factors following abrasion. These are desiccation and increased penetration of the toxicant. Their relative importance probably depends upon differences in climatic factors such as temperature and relative humidity which may favor one or the other.

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Toxicity Tests of Some New Insecticides[1]

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The past few years have seen the release of several new insecticides into the field of chemical control of insects. It is the object of this paper to present some preliminary results on the effectiveness of three of these new materials against several insect pests of truck crops in Tidewater, Virginia. The materials tested were: (1)DDT, (dichloro-diphenyl-trichloroethane); (2) chlordane, a chlorinated hydrocarbon with the empirical formula $C_{10}H_6Cl_8$; and (3) benzene hexachloride.

The data in this paper were analyzed by Fisher's Analysis of Variance. The minimum difference for significance presented in the tables are at odds of 19:1.

PICKLEWORM.—Field experiments for the control of the pickleworm, *Diaphania nitidalis* (Stoll), were divided into two plantings; the first cantaloupes and the second cucumbers. The cantaloupes formed an early summer planting, and each treated block consisted of three rows 180 feet long, replicated three times. A horse-drawn motor-driven duster was used in applying the dusts to the cantaloupes. The cantaloupes received two treatments at about 10 day intervals starting shortly after the first blossoms appeared.

The cucumber plot was a late summer planting, and each block consisted of three rows 30 feet long, replicated three times. Dust applications were made with a hand type rotary duster. Three applications were made, one at the time the first blossom appeared and the others at weekly intervals thereafter.

The effectiveness of the materials in the cantaloupe plot was evaluated by counting the number of wormy and clean fruits present on the middle row of each block. In the cucumber plot, due to the presence of disease and to unfavorable weather conditions it was impossible to obtain any insect damage data; however, plant stand counts were made to determine the phytotoxic effect of the treatments.

As seen in table 1, a benzene hexachloride dust containing 1 per cent gamma isomer was the most effective material tested for the control of pickleworm on cantaloupes. Three per cent DDT dust mixtures were significantly superior to the 2 per cent DDT dusts. A 1 per cent DDT impregnated dust mixture ranged in effectiveness between the 3 and 2 per cent regular mixed DDT dusts; this indicates the impregnation process may have increased the toxicity. Dust mixtures containing benzene hexachloride (0.5 per cent gamma), 90 per cent cryolite, and 5 per cent chlordane were the least effective materials tested but results were significantly better than those in the untreated check. Gross examination of the plots did not reveal any foliage injury resulting from treatments.

In the cucumber plot, a benzene hexachloride (1 per cent gamma) dust mixture caused a significant reduction in plant stand while DDT and *Velsicol 1068* mixtures caused a slight chlorosis of the new leaves but did not cause any reduction in stand.

In a large scale test conducted by a commercial grower using benzene hexachloride (1 per cent gamma), 3 per cent DDT, and a cryolite dust mixture on cucumbers, noticeable burning occurred on the new growth of the plants treated with the benzene hexachloride dust when used at the rate of about 30 pounds per acre. The other two materials caused no noticeable injury to the plants.

Greenhouse tolerance tests on three varieties of cantaloupes and two of cucumbers with benzene hexachloride (1 per cent gamma), 3 per cent DDT, and 5 per cent chlordane dust mixtures showed the benzene hexachloride dust to cause severe injury to the new growth of the plants, while the DDT and *Velsicol 1068* mixtures caused a slight trace of chlorosis and slight malformation of the new leaves.

HAWAIIAN BEET WEBWORM.—The spinach field selected for this experiment was located on the L. Hill farm in Princess Anne County, Virginia. The plants were nearly mature and contained a uniform heavy infestation of the Hawaiian beet

[1] Eastern Branch Program.

[2] For supplying certain materials used in these studies, the writers wish to express their appreciation to the following: American Cyanamid & Chemical Corporation, E. I. duPont de Nemours & Co., Inc., Grasselli Chemicals Dept., Niagara Sprayer and Chemical Company, Inc., Pennsylvania Salt Manufacturing Company, and the Velsicol Corporation.

Table 1.—Effect of treatments on control of the pickleworm on cantaloupe and phytotoxicity to cucumbers.

TREATMENTS DUST MIXTURES[1]	CANTALOUPE PLOT			CUCUMBER PLOT		
	Pounds per Acre		Av. Wormy Melons	Pounds per Acre	Av. No. Plants Dead	Plants Dead
	Aug. 15	Aug. 24	Aug. 28			
Benzene hexachloride (33% gamma) 3 lbs. +neutral copper 10 lbs.+*Pyrax ABB* 87 lbs.	56	42	3%	40	23.8	79%
DDT 3 lbs.+*Pyrax ABB* 97 lbs.	54	47	18%			
DDT 3 lbs.+neutral copper 10 lbs.+*Velsicol AR-60* 2 lbs.+*Pyrax ABB* 85 lbs.	44	40	21%	35	6.0	22%
DDT 1 lb. in 2 lbs. *Velsicol AR-60* (Impregnated)+neutral copper 10 lbs.+*Pyrax ABB* 87 lbs.	42	38	25%			
DDT 2 lbs.+neutral copper 10 lbs.+*Pyrax ABB* 88 lbs.	47	42	32%			
DDT 2 lbs.+neutral copper 10 lbs.+*Velsicol AR-60* 2 lbs.+*Pyrax ABB* 86 lbs.	46	39	33%			
Velsicol Chlordane 5 lbs.+neutral copper 10 lbs. +*Pyrax ABB* 85 lbs.	60	44	39%	44	11.5	38%
Cryolite 90 lbs.+neutral copper 10 lbs.	58	38	40%	38	6.8	20%
Benzene hexachloride (33% gamma) 1.5 lbs. +neutral copper 10 lbs.+*Pyrax ABB* 88.5 lbs.	51	40	44%			
Untreated Check	—	—	65%	—	11.4	38%
Minimum difference for significance			9.07		8.2	

[1] All copper-containing dust mixtures were prepared from neutral or insoluble copper compounds that had a metallic copper content of 50 per cent.

webworm, *Hymenia recurvalis* (F.). Each plot consisted of two beds, each 5 feet wide and 550 feet long, replicated three times. Applications were made by a 1917 model horse-drawn traction type duster which had a very low wind velocity output. The duster had a 12-foot trailer attached to it, and was so adjusted that four nozzles covered a single bed. Worm population counts were made after treatment by selecting at random 40 lower leaves in each plot.

The results as shown in table 2, indicate the benzene hexachloride (1 per cent gamma isomer) was significantly more effective than either of the pyrethrin containing dust mixtures. There was not a significant difference between the two pyrethrin dust mixtures; however, it is of interest to note the synergistic effect of piperonyl-cyclohexenone which increased the toxicity of a 0.04 per cent pyrethrin dust so that it equaled the effectiveness of a 0.2 per cent pyrethrin dust. Observations made on commercial applications of low pyrethrin content piperonyl-cyclohexenone dust mixtures confirm indications that this mixture is just as effective as a higher pyrethrin content dust without the synergist.

Table 2.—Effectiveness of treatments against the Hawaiian beet webworm on spinach.

TREATMENTS DUST MIXTURES	POUNDS PER ACRE	AVERAGE NUMBER OF WORMS PER 40 LEAVES		CONTROL OVER CHECK
		1 Day	4 Days	
Benzene hexachloride (1% gamma)—*Pyrax ABB*	53	16	0	100%
0.2% Pyrethrins (*Stimtox A*)—*Pyrax ABB*	44	37	24	59%
0.04% Pyrethrins (*Stimtox A*) 0.4% Piperonyl cyclohexenone—*Pyrax ABB*	50	33	25	55%
Untreated Check	—	87	60	—
Minimum difference for significance		11.7	8.12	

The poor kill obtained with the pyrethrin materials might be explained in part as the result of poor coverage. The control of this insect by the benzene hexachloride dust was very outstanding, since in going over these treated plots carefully, living worms were not observed.

In a laboratory test with the same materials using potted spinach plants infested with well established worms, similar results were obtained. The plants were dusted with a small hand dust atomizer.

After 24 hours a count gave the following results: benzene hexachloride (1 per cent gamma) dust 100 per cent control, 0.2 per cent pyrethrin dust 88 per cent, and a 0.04 per cent pyrethrin +0.5 per cent piperonyl-cyclohexanone dust mixture 92 per cent control.

In the fall of 1945 a field experiment was conducted on the webworm testing pyrethrum, sabadilla, and DDT dust mixtures, and pyrethrum and DDT in the aerosol form. The results obtained showed a pyrethrum dust, and pyrethrum and DDT in the aerosol form to be very effective; a 10 per cent DDT dust gave only fair control; and a sabadilla dust mixture was ineffective against the webworm.

SEED TREATMENTS.—Two varieties each of sweet corn, snap beans and lima beans were used in the test. Each treatment plot consisted of a row 25 feet long in which 25 seeds were planted, each treatment was replicated four times. To insure intimate contact of the insecticide with the seed, the materials were placed in the rows at the time of planting, and were also coated on the seed. To increase the amount of dust adhering to the seed a sticking agent was used. The sticking agent was prepared from *Methocel* and water (Newhall 1945).

A 3 per cent DDT dust and a benzene hexachloride (0.3 per cent gamma) dust were applied in the rows at the rate of 175 pounds per acre. A 10 per cent DDT dust was applied to the seeds at the rate of about 7 pounds per bushel and the 0.5 per cent gamma benzene hexachloride at 12 pounds. The soil in which the seeds were planted is classified as being a Woodstown Sandy Loam with a pH range of 5 to 5.5. Germination or stand counts were made two weeks after planting.

The results shown in table 3 indicate that the benzene hexachloride coated on the seeds caused considerable reduction in germination, except in the Black Valentine snap beans and Aristagold sweet corn. The failure of benzene hexachloride to injure Aristagold sweet corn when coated on the seed, was perhaps due to the light dose of gamma benzene hexachloride in this case, which was only 0.4 ounce per bushel. When it was applied in the row and not on the seed only the two varieties of sweet corn were injured.

DDT on the seeds caused significant reduction in the germination of Golden Cross Bantam sweet corn and Henderson Bush lima beans, whereas there was little or no injury resulting where the material was applied in the rows.

It is of interest to note that where the germination of the untreated lots of seeds was poor, the injury resulting from the applications of insecticides was greatly increased.

After the treated (coated) seeds had been stored for a period of six months, small scale germination tests were run in the greenhouse with the following results: Black Valentine snap beans treated with benzene hexachloride had 16 per cent germination, DDT treated 88 per cent, and untreated 96 per cent; Bountiful snap beans a germination of 28 per cent for the

Table 3.—Effect of treatments on seed germination.

	TOXICANT ON SEED (PER BUSHEL)		PER CENT GERMINATION				
SEED VARIETIES	DDT	Benzene Hexachloride as Gamma	DDT on Seeds	Benzene Hexachloride on Seeds	DDT in Row 5.25 lbs. per Acre	Gamma Benzene Hexachloride in Row 0.5 lbs. per Acre	Untreated Check
Aristagold Sweet Corn	9.3 oz.	0.4 oz.	89%	73%	85%	65%	78%
Golden Cross Bantam Sweet Corn	10.8 oz.	1.3 oz.	31%	5%	52%	35%	49%
Bountiful Snap Bean	11.8 oz.	0.8 oz.	84%	47%	91%	82%	79%
Black Val. Snap Bean	12.8 oz.	1.2 oz.	88%	72%	89%	89%	77%
Henderson Bush Lima Bean	7.7 oz.	0.9 oz.	31%	2%	48%	48%	52%
Fordhook Lima Bean	10.0 oz.	0.8 oz.	49%	11%	61%	48%	52%
Minimum difference for significance			13.8[1]				

[1] This figure is for significance between any of the percentages.

benzene hexachloride, 68 per cent for the DDT, and 100 per cent for the untreated; the Henderson Bush lima beans had none in the benzene hexachloride lot, 68 per cent in the DDT, and 80 per cent in the untreated seeds; and in Aristagold sweet corn treated with benzene hexachloride none, and 80 per cent in the DDT treated seeds.

GLADIOLUS THRIPS.—This small field test for the control of the gladiolus thrips, *Taeniothrips simplex* (Mor.), was located on the Tidewater Bulb Farm near Oceana, Virginia. The test plot was set up in a single row of very heavily infested gladiolus of the Mother MaCree variety. Each treatment block consisted of a portion of the row 20 feet long; a single treatment being replicated four times. A hand type rotary duster was used in applying the dusts and the nozzle was directed to cover both sides of the plants. The sprays were applied with a knapsack type sprayer and the spray was directed at the top and sides of the plants. At the time of treatment the petals of the flowers were just starting to show at the ends of the buds.

Population counts were made by counting the number of living and dead adults and nymphs in the bottom flower bud. Counts were made 3 days after the treatment had been made. A single bud from 12 different plants in each plot was taken as the sample.

As shown in table 4, the benzene hexachloride materials were by far the most effective tested. The benzene hexachloride (1 per cent gamma) dust mixture was superior to the spray mixtures. This effectiveness was due undoubtedly to the volatility of the material which killed the insects within the buds. The control obtained was very noticeable to the eye, and enabled the grower to harvest flowers from these plots, whereas in the other treated blocks the flowers were a total loss.

Some of the poor results given by other materials might have been due to the two rains which occurred within the time between treatment and the counts. In a large scale test put on in cooperation with the grower, DDT, benzene hexachloride, and tartar emetic were used in the spray form. The materials were applied with a power sprayer using three nozzles to the row at the rate of about 75 gallons per acre. Treatments were applied at about weekly intervals. Observations made after three applications, indicated that DDT and benzene hexachloride materials gave about the same control, which was fair, but both were superior to the control obtained with tartar emetic brown sugar mixture.

POTATO INSECTS.—These tests were conducted on Irish Cobbler potatoes on the Wilkerson farm near New Church, Virginia. Each treatment plot consisted of 4 rows about 310 feet long and were replicated four times. The principal insects present in these plats were potato flea beetle, *Epitrix cucumeris* (Harr.), and the potato aphid, *Macrosiphum solanifolii* (Ashm.). The spray materials were applied with a sprayer operating at 250 pounds pressure, the nozzles being equipped with No. 3 spray discs. Three nozzles were used to a single row. The dust

Table 4.—Effectiveness of treatments against the gladiolus thrips.

TREATMENTS SPRAYS AND DUSTS	AMOUNT PER ACRE	DEAD THRIPS ON 12 BUDS AFTER 3 DAYS	PER CENT KILL
Benzene hexachloride W.P.[1] (7.5% gamma) 1 lb. to 100 gallons of water	100 gals.	66	50.0
DDT 50% W.P. 2 lbs. to 100 gallons of water	100 gals.	13	10.8
Benzene hexachloride W.P. (7.5% gamma) 1 lb.—Kerosene type oil emulsion 2 qts. to 100 gallons of water	100 gals.	43	46.8
DDT 25% oil emulsion 1 qt. to 100 gallons of water	100 gals.	8	6.5
Tartar emetic 4 lbs.—Brown sugar 6 lbs. to 100 gallons of water	100 gals.	8	4.1
DDT 1 lb. in 2 lbs. *Velsicol AR-60* (Impregnated)+*Pyrax ABB* 97 lbs.	50 lbs.	12	9.2
Benzene hexachloride (33% gamma) 3 lbs.+clay 97 lbs.	50 lbs.	108	86.6
Untreated Check	—	6	1.9
Minimum difference for significance		23.6	

[1] W.P. = Wettable powder.

mixtures were applied with a horse-drawn traction duster using two nozzles to a single row. The first treatments were applied at the time when the plants were blossoming, and were continued at about weekly intervals for a total of five treatments.

Insect population counts were made at the termination of the treatment period. The aphid population counts were made by counting the number of aphids present on 15 terminal leaflets in each treatment block. To determine the flea beetle population, 25 leaflets were selected in each block. A given portion of each of these leaves was taken and examined for feeding scars to give a population index (Anderson & Walker 1936).

The results as shown in table 5, show that a DDT spray mixture was very effective against the potato aphid, and a benzene hexachloride (0.6 per cent gamma) dust was superior to a 3 per cent DDT dust mixture. On the potato flea beetle there was little or no difference between the various dust treatments; however, in the spray mixtures, a Bordeaux spray containing calcium arsenate was superior to a DDT-insoluble copper mixture. This marked difference between the two spray materials may be due to the amount of deposit present on the foliage at the time the flea beetle infestation occurred. The Bordeaux treated plots had by far the greatest amount of deposit present on the foliage 19 days after treatment.

TURNIP APHID.—Two laboratory tests were made with certain of the new insecticides on the turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis). Kale leaves infested with aphids were brought in from the field and dusted by means of a small dust atomizer. Three leaves containing approximately 200 aphids were used in a single test, and each test was replicated three times. All of the leaves received approximately the same amount of dust and were exposed for the same length of time in a dust chamber. After treatment the leaves were placed on moist blotting paper in large (19.5 cm. diameter) uncovered petri dishes which had received a band of grease on the upper rim to prevent migration of the aphids. Mortality records were made at the end of 24 hours.

The results of these tests are given in table 6. A benzene hexachloride (1 per cent gamma isomer) dust mixture was the most effective material tested and was significantly better than the 3 per cent nicotine dust mixtures. There was not a significant difference between the two nicotine dust mixtures prepared from *Black Leaf 40* and *Black Leaf 14*. DDT and chlordane dust mixtures were not significantly better than the untreated check.

CORN INSECTS.—Tests were made on corn for the control of corn lantern fly, *Peregrinus maidis* (Ashm.) as well as the fall armyworm, *Laphygma frugiperda* (A. & S.). The experimental plot was a

Table 5.—Effectiveness of treatments against the potato flea beetle and the potato aphid.

TREATMENTS SPRAYS AND DUSTS	AMOUNTS PER ACRE	AV. NO. APHIDS PER LEAFLET AFTER		AV. NO. FLEA BEETLE FEEDING SCARS PER LEAFLET AFTER
		4 Days	9 Days	19 Days
	Gals.			
Calcium arsenate 4 lbs. in Bordeaux (4-4-50)	114	171	167	63.6
DDT 50% W.P.[1] 2 lbs.+Neutral copper[2] 5 lbs. in 100 gallons of water	114	11	42	173.0
	Lbs.			
Calcium arsenate 10 lbs.+Mono. Hyd. Copper Sulfate 20 lbs.+lime 70 lbs.	46	180	193	301.0
DDT 3 lbs.+Neutral copper 10 lbs.+*Pyrax ABB* 87 lbs.	46	92	94	280.0
Benzene hexachloride (12% gamma isomer) 5 lbs. +Neutral copper 10 lbs.+*Pyrax ABB* 85 lbs.	46	61	42	336.3
Minimum difference for significance		60.4	40.7	176.3

[1] Wettable powder.
[2] Neutral copper material contained approximately 50% copper as metallic.

Table 6.—Laboratory tests of materials on the turnip aphid.

Treatments Dust Mixtures	Test I		Test II	
	Dead Aphids per Rep. After 24 Hours	Kill	Dead Aphids per Rep. After 24 Hours	Kill
Benzene hexachloride (1% gamma isomer)—*Pyrax ABB*	182.6	91.5%	200	100%
3% Nicotine[1]—Lime			134	67%
3% Nicotine[2]—Lime	25.7	13.0%	116	58%
3% DDT—*Pyrax ABB*	4.3	2.0%		
5% Chlordane—*Pyrax ABB*	3.1	1.5%		
Untreated Check	2.2	1.0%	5	3%
Minimum Difference for Significance	6.9		58.4	

[1] *Blackleaf 14.* [2] *Blackleaf 40.*

late planting of sweet corn. A plot consisted of three rows 85 feet long, and each treatment was replicated three times. The first application of insecticides was made when the corn was about three inches in height; two other applications were made at weekly intervals. The dusts were applied with a hand rotary duster, the nozzle being directed at the whorl of the plant. The insect population counts were made after the third treatment had been applied. Stand counts were made at the beginning of the treatments and again at their termination.

The results obtained, table 7, indicate little difference in the effectiveness of a benzene hexachloride (1 per cent gamma), 3 per cent DDT, and 5 per cent chlordane dust mixtures on the corn lantern fly and the fall armyworm. The 1 per cent DDT impregnated dust appeared to be less effective against the corn lantern fly than the benzene hexachloride, *Velsicol 1068*, and 3 per cent DDT materials; however, it was not significantly inferior to the 3 per cent DDT dust on the fall armyworm.

The lead arsenate plots had more corn lantern flies than the check plots, which may have been the result of the unattractiveness of the check plants. The lead arsenate plots showed some plant injury in the form of a slight burning and stunting of the plants.

BARRIER TESTS AGAINST THE FALL ARMYWORM.—The test was conducted in a field of soybeans in which a heavy and uniform population of fall armyworms, *Laphygma frugiperda* (A. & S.), had eaten all of the volunteer grasses. The worms were starting to migrate to nearby fields and offered an excellent opportunity to evaluate insecticides as to their effectiveness in a barrier. A furrow was dug with a hand plow directly across the middle of the infested field, and was divided off into

Table 7.—Effectiveness of treatments against the corn lantern fly and fall armyworm on corn.

Treatments Dust Mixtures	Pounds per Acre	Flies per 25 Plants After: 24 Hrs.	72 Hrs.	Control Over Check	Worms per 20 Plants After 72 Hrs.	Control Over Check	Mean No. Miss. Plants	Reduct. in Stand
Benzene hexachloride (1% gamma)—*Pyrax ABB*	26.5	11	12.0	79%	7.3	94%	6.6	8%
3% DDT—*Pyrax ABB*	27.5	27	19.0	67%	8.3	93%	12.3	16%
5% Chlordane—*Pyrax ABB*	28.25	32	22.0	62%	2.7	98%	5.0	10%
1% DDT (Impregnated)—*Pyrax ABB*	23.5	35	31.3	45%	14.7	88%	8.6	12%
Lead arsenate	14.0	71	61.6	0%	50.0	60%	18.6	24%
Untreated Check	—	78	56.6	—	126.0	—	28.0	36%
Minimum difference for significance		17.1	18.1		16.1		6.5	

FIG. 1.—Dust barrier for fall armyworm control. A. Barrier plats.

sections in which the materials were placed (Fig. 1). Each treatment plot was 15 feet in length and replicated three times. The materials were used at the rate of one and three quarters pounds per 100 feet of furrow. Population counts were made 24 hours after treatment by counting the number of dead worms in the furrows and within an area fifteen by six feet on each side of the furrow (Fig. 2).

Table 8, shows that a benzene hexachloride (1 per cent gamma) dust mixture was the most effective material tested for the retarding of the fall armyworm. This material was significantly better than a 5 per cent chlordane dust, but not significantly better than a 3 per cent DDT dust mixture. The effectiveness of the benzene hexachloride mixture may be due in part to the rapidity of action as compared to the other materials; however, dead worms were not found in the immediate area of the other plots.

A rain occurred 6 hours after the materials had been placed in the barrier; 24 hours later the effectiveness of all materials were greatly reduced due to caking.

FIG. 2.—Fall armyworm larvae collected in depression in barrier furrow.

BAIT TESTS AGAINST THE FALL ARMYWORM AND THE BLACK CUTWORM.—Bait formulations containing DDT, chlordane, benzene hexachloride, and paris green were prepared with bran as the carrier and with oil and other solvents as the conditioner. The baits were tested in the laboratory and in the field against the fall armyworm, *Laphygma frugiperda* (A. & S.), and the black cutworm, *Agrotis ypsilon* (Rott.).

The general formula of the bait mixtures by weight was as follows: bran—25 parts; oil or oil and solvent—5 (16 per cent) parts; and toxicant 1 (3 per cent) part. Where the toxicant was lowered the bran content was increased. Except for paris green, all toxicants were dissolved in the oil or oil-solvent mixture before being mixed with the bran; and in certain cases it was necessary to heat the solutions to insure a complete solubility.

Table 8.—Effectiveness of certain insecticides on the fall armyworm when used in a barrier.

TREATMENT DUST MIXTURE	DEAD WORMS PER FOOT AFTER 24 HOURS
Benzene hexachloride (1% gamma) —*Pyrax ABB*	6.03
3% DDT—*Pyrax ABB*	4.29
5% Chlordane—*Pyrax ABB*	2.54
Untreated Check	0.04
Minimum difference for significance	2.62

The evaluation of baits on the fall armyworm was divided into two tests; one cage test and one field test. In the cage test, 10 worms were placed within a screen cage with a small amount of bait and some natural food; after a period of four hours the bait was removed. Each bait treatment was replicated three times. Mortality records for the cage tests were made at 4 and 24 hours. For the field tests locations were selected at random within the infested field and the bait was scattered around a marked stake. The area treated was about 16 feet in diameter and well separated from the other treatment plots. All treatments were replicated three times. Mortality counts were made at the end of 24 and 48 hours by counting the number of worms present within an

area of four square feet. The baits were broadcast at the rate of about 25 pounds per acre.

The bait tests on the black cutworm were conducted in the laboratory with third and fourth instar larvae obtained from the field. The worms were placed in large glass jars containing soil and a single partially grown kale plant. Five worms were placed in each jar in individual depressions and covered to prevent cannibalism. A ring of bait was placed around the plant about two inches from the stem. It was necessary for the cutworm to cross the ring of bait in order to feed on the plant. Each test was replicated three times. Mortality counts were made at the end of 48 hours.

The results of the bait tests against the fall armyworm and the black cutworm are shown in table 9. In the cage tests with fall armyworms, a bait containing 1.5 per cent chlordane was significantly better than any other formulation tested. The bait formulations containing 1.5 per cent DDT were just as effective as a bait having 3 per cent of paris green as the toxicant. A bait with benzene hexachloride (0.2 per cent gamma) as the toxicant was significantly inferior to all of the materials tested against the fall armyworm in the cage tests.

Field tests of bait formulations against the fall armyworm show that a bait containing 1.5 per cent chlordane was significantly better than a 3 per cent paris green bait. A bait containing 0.2 per cent gamma benzene hexachloride and one with 1.5 per cent DDT and 16 per cent *Velsicol AR-60* were significantly inferior to a paris green bait. The remainder of the baits tested ranged in effectiveness bebetween the chlordane and paris green baits.

The results of the laboratory tests of bait formulations against the black cutworm show that a bait formulation containing 3 per cent DDT was significantly better than the paris green bait. The other baits were just as good as the paris green bait, and were not significantly inferior to the 3 per cent DDT bait. All bait formulations were significantly better than the check material containing bran with 16 per cent oil (S.A.E. 10).

REMARKS.—Small scale laboratory and field tests with a benzene hexachloride (1 per cent gamma isomer) dust and a spray mixture containing four ounces of benzene hexachloride (30 per cent gamma isomer)

Table 9.—Toxicity of various bait formulations to the fall armyworm and the black cutworm.

BAIT FORMULATIONS[1]	FALL ARMYWORM						CUTWORM	
	Cage Tests			Field Tests			Laboratory Tests	
	Worms Moribund 4 Hrs.	Worms Dead After 24 Hrs.	Kill	Worms Dead After 24 Hrs.	Worms Dead After 48 Hrs.	Kill	Worms Dead After 48 Hrs.	Kill
3% Paris green—16% oil—Bran	2.0	7.0	70%	17.5	19.1	63%	1.3	27%
Benzene hexachloride (0.2% gamma) —5% Xylene—11% oil—Bran	3.3	4.4	44%	7.2	10.9	36%		
1.5% DDT—5% Xylene—11% oil —Bran	1.3	5.8	58%	8.8	24.8	83%	2.0	40%
3% DDT—5% Xylene—11% oil— Bran							4.0	80%
1.5% DDT—5% *Velsicol AR-60*— 11% oil—Bran	0.9	7.2	72%	10.6	18.7	62%		
1.5% DDT—16% *Velsicol AR-60*— Bran	2.1	5.5	55%	3.2	6.0	20%		
1.5% DDT—16% oil—Bran	1.4	6.2	62%	13.3	23.8	79%		
1.5% Chlordane—5% Xylene—11% oil—Bran	6.4	10.0	100%	20.8	27.9	93%	3.3	67%
3% Chlordane—5% Xylene—11% oil—Bran							3.0	60%
17% oil—Bran							0.6	13%
Minimum difference for significance	1.7	1.8		5.7	6.3		2.02	

[1] The oil used in these baits was S.A.E. grade 10.

per 100 gallons of water were found to be effective against the adults of the Japanese beetle. Tests of DDT wettable powders and oil emulsions containing DDT against the Japanese beetle indicate that on the basis of equal DDT content the wettable powder was superior.

A benzene hexachloride (1 per cent gamma) dust was found to be effective against the nymphs and adults of the harlequin cabbage bug when tested in the laboratory.

Laboratory tests of a bait formulation containing 0.2 per cent gamma benzene hexachloride, on a group of mixed species of grasshoppers indicate it was very effective, and they seemed to like the bait. The same bait tested against the black cutworm appeared inferior, and the worms seemed to dislike it.

The results of large scale field tests against the pea aphid in the spring 1946, clearly indicated that a benzene hexachloride (1 per cent gamma) dust and certain DDT dust mixtures were very effective in controlling this insect (Anderson & Brooks 1946).

Observations made in cucumber and cantaloupe plots treated with a benzene hexachloride (1 per cent gamma isomer) dust indicate the material was effective against the melon aphid, and the striped and spotted cucumber beetles. A 1 per cent DDT impregnated dust was also found to be effective on the striped and spotted cucumber beetles.

A field test of dust mixtures containing chlordane, DDT, benzene hexachloride, cryolite, and lead arsenate on late fourth instar larvae of the fall armyworm failed to show effective control with any of the mixtures. The poor control may have been the result of the worms being ready to pupate and therefore more resistant to insecticides.

The results of a field test of DDT, chlordane, and benzene hexachloride dust mixtures on the imported cabbage worm indicate that a benzene hexachloride dust was inferior to the other two materials in the control of this insect.

Kale treated with a benzene hexachloride (1 per cent gamma isomer) dust was cooked 48 hours later, and although the leaves were unwashed, it was not possible to detect any musty odor during the cooking or later.

SUMMARY.—Preliminary toxicity studies were made with DDT, chlordane, and benzene hexachloride on several insect pests of truck crops growing in the Tidewater section of Virginia.

The results of these studies indicate the following:

1. A benzene hexachloride (1 per cent gamma) dust mixture was effective against the Hawaiian beet webworm, corn lantern fly, fall armyworm, gladiolus thrips, pickleworm, and turnip aphid. A dust mixture containing benzene hexachloride (0.6 per cent gamma) was effective on the potato aphid. The benzene hexachloride materials as used in these studies were found to reduce the germination of seeds. Under certain conditions a benzene hexachloride (1 per cent gamma) dust caused severe injury to the new growth of cucumbers and cantaloupes.
2. DDT dust mixtures were found to be effective against the corn lantern fly, fall armyworm, potato aphid, and pickleworm. DDT used in a spray mixture was found effective on the potato aphid. DDT used in baits tested on the fall armyworm and black cutworm were found effective. In germination studies, DDT was found to cause very little reduction of the germination of the seeds tested. The new growth of cucumbers and cantaloupes under certain conditions was injured slightly by the application of a 3 per cent DDT dust.
3. Chlordane dust mixtures were found effective against the corn lantern fly and the fall armyworm. Used in baits, chlordane was effective on the fall armyworm and the black cutworm. A 5 per cent chlordane dust mixture caused slight injury to the new growth of cucumbers and cantaloupes when applied under certain conditions.
4. Piperonyl-cyclohexenone was found to be an effective synergist for pyrethrum.—11-21-46.

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A Twig Droop of White Pine Caused by *Pineus*[1]

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In the spring of 1943 the authors' attention was called to a disturbance of young white pines in a stand southwest of Highlands, N. C., by Professor C. C. Newman of Clemson College. Specimens of small trees submitted by him were characterized by sharply drooped twigs with greatly reduced growth distal to the point of bending. Moreover, some of the twigs were heavily infested with immature stages of chermids.

Examinations of the stand in June revealed that the drooping and stunted growth (figs. 1 to 3) were especially common among small trees growing in the

Fig. 1.—White pine showing severe drooping and stunted internode and foliage growth.

shade and on twigs of the lower branches of larger trees. Many twigs were bent down sharply in an internode that had developed from 1 to 3 years prior to examination, and the growth after the bending was usually greatly reduced, sometimes less than half as great as the annual growth that was made before the shoot was bent. When the bending was at the base of the current year's growth, the twigs were limp, with a marked loss in

Fig. 2.—Whorl of current season's twigs badly drooped.

Fig. 3.—Two-year-old lateral white pine twig showing droop of current season's growth.

rigidity at the point of the bend. The branch terminals of some malformed trees were heavily infested with tiny scalelike chermids, but others were uninfested.

[1] Chermidae.
[2] Bureau of Entomology and Plant Quarantine.
[3] Bureau of Plant Industry, Soils and Agricultural Engineering.

Small trees were most severely affected by this condition, and a few had been killed. Some of the larger trees, between 15 and 20 feet in height, were making good growth and appeared healthy, even though some of the twigs were infested with chermids; other trees, however, appeared unsightly because of malformed branches accompanied by dead, broken-over and hanging terminals.

Several stages of immature chermids associated with the crooked terminals were identified[1] as *Pineus strobi* (Hartig), a species commonly referred to as the pine bark aphid. Since this species had not previously been observed causing such a deterioration and since no disease was known to act in this manner, other causes were sought. It was postulated that the disfiguration might have been caused by sleet or snow, but this was refuted because many current year's shoots were bent before winter, and many that were very limp in the spring had become stiffened when examined in August. This observation suggested that the trouble was caused earlier in the summer or in the spring, and that the associated chermids were probably involved.

Late in February 1944 the unsightly condition of the trees was more pronounced than in the previous fall since a portion of the older needles had been dropped. A small number of terminals on some trees had died, but no branch breakage was observed. First-stage chermid nymphs, only a few of which were alive, infesting the crooked terminals of bowed branches, were identified as *Pineus* sp., differing from known stages of *P. strobi* and, according to Miss Russell, not agreeing with the described stages of any species. Chermids associated with malformed white pine twigs were also observed near Cashiers, N. C., and on exposed trees along the highway approximately 7 miles east of there. First-stage young of *Pineus* sp., apparently the same form as those taken at Highlands, were also found on similarly disfigured white pine twigs collected in November 1945 at Canton, N. C.

Observations in Canada during August 1944 showed the same type of damage on small white pines at Lake Kipawa in Quebec and on one shoot of a white pine tree, 6 inches in diameter, in Algonquin Park, Ontario. This shoot, which was bowed, with the terminal growth upturned, was infested with chermids subsequently identified as *Pineus* sp. Careful search failed to disclose other deformed twigs or the presence of additional chermids on this tree. Balch & Hawboldt (1943) recorded considerable damage to new white pine shoots by *Pineus pinifoliae* (Fitch) near Shirley, New Brunswick. They mentioned that this species produced a characteristic distortion of young growing shoots that prevented the normal growth of lateral terminals in a horizontal direction and eventually resulted in crooked growth. Moreover, they observed browned terminal shoots, a reduction in wood growth, and the death of a few trees caused by this species.

In order to determine whether the chermids might be responsible for the situation at Highlands, it was decided to spray some of the affected trees periodically to eliminate the insects and to compare the new shoot growth of these trees with that of unsprayed trees near by. The following spray was used:

White oil emulsion (80% of oil)	1 pint
Nicotine sulfate (40%)	2 tablespoonfuls
Soap (flakes)	3 ounces
Water	3 gallons

Eight young and weakened trees with drooped twigs were sprayed on July 7 and August 29, 1944, and on June 29, 1945. The foliage of some trees was injured by spray burn. When the sprayed trees were examined on April 27, 1945, they were free of chermids. In the case of the largest tree, only one side branch of which was sprayed, that branch was free of the chermids, whereas the other lower branches were infested. Twigs of unsprayed trees intermixed with the sprayed trees were heavily infested with egg masses, larvae, and mature forms of *Pineus* sp., the first-stage larvae being identical with those found in February 1944.

On September 20, 1945, data were taken on the trees to determine the effect of the spraying on the twig droop. The unsprayed trees showed a high percentage of drooped twigs in 1945, whereas the sprayed trees showed no drooping and a growth greater than in 1944.

Since the sprayings that effectively con-

[1] All identifications referred to in this note were made by L. M. Russell, of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine.

trolled these insects also checked the droop and permitted accelerated growth, and since unsprayed trees were heavily infested with the chermids and developed the drooping and reduced growth, *Pineus* sp. is regarded as the cause of the white pine twig droop. This form represents unknown stages of a recognized species or else a new species. White pines, used as ornamentals and as shade trees, that become infested with these chermids can be protected by making a thorough application of a standard oil emulsion spray before the population is abundant enough to cause damage. —12-5-46.

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Weed Hosts of Bugs Which Cause Cat-Facing of Peaches in Virginia[1]

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In recent years cat-facing of fruits has been an important and increasing cause of losses to peach growers in Virginia. The insects chiefly responsible for this scarring have been stinkbugs of the genus *Euschistus* and the tarnished plant bug, *Lygus oblineatus* (Say), (Woodside 1946). Since these bugs breed on peach to a very small extent, if at all, they are dependent upon weed and crop-plant hosts for their reproduction in sufficient numbers to be of economic importance. Haseman (1918) found that the control of the weed hosts of the tarnished plant bug near nurseries practically eliminated injury to nursery stock by this bug.

Various cover crops, particularly some of the legumes, have been blamed for high infestations of both the stinkbugs and the tarnished plant bug in peach orchards. Porter *et al.* (1928) reported that *Euschistus* spp. bred on red clover, and that these bugs were very common in fields of cowpeas and soybeans in Indiana and Illinois late in the season. The same authors reported that the tarnished plant bug bred freely on legumes. Rice (1937) attributed severe cat-facing of peaches in a Delaware orchard to the proximity of a field of crimson clover.

COVER CROPS OF SLIGHT IMPORTANCE. —Observations and collections of insects from cover crops in peach orchards over a period of 4 years have not indicated that cover-crop plants are important as hosts of either the stinkbugs or the tarnished plant bug in Virginia orchards. This has been true even in orchards where peaches had repeatedly suffered severe damage in the form of cat-facing. No significant infestation of any of these bugs has been found on any crop plant except scattered plants of sweet clover. Both nymphs and adults of the tarnished plant bug have been collected from sweet clover in considerable numbers, but this plant has never been found as heavily infested as several of the common weed hosts of this bug. The infestations found on red clover have been even lighter. The stinkbugs, except for an occasional individual, have not been found on any cover crop in a peach orchard, and no evidence has been found that they breed on the legumes in significant numbers in Virginia. *Euschistus servus* (Say), the brown stinkbug, is sometimes common on tobacco; *E. variolarius* (Pal. de B.), the spined stinkbug, is often found in considerable numbers on corn, tomato, and tobacco; and *E. tristigmus* (Say) may be found on tomato, tobacco, lima bean, and snap bean.

Hosts of Euschistus spp.—During the 1946 season many collections of insects were made from weeds in and near peach orchards in the counties of Albemarle, Augusta, Buckingham, and Rockingham. *Euschistus servus* and *E. tristigmus* were often found on the same species of weeds. The favorite host of both of these stinkbugs was white-top fleabane, *Erigeron annuus* (L.) Pers. This weed is common throughout the territory where these col-

[1] Eastern Branch Program.

lections were made. It is often found in uncultivated or poorly cultivated orchards, but it is more common along the edges of orchards and in uncultivated fields. It blooms chiefly in June and July, but a few plants bloom much later. During the period from blooming to maturity nymphs of *E. servus* and *E. tristigmus* were often common on this weed, and it was the favorite host of the first generation of both species. After the maturing of the seeds in July, the infestation of the bugs dropped as they reached the adult stage and migrated to more attractive hosts, and very few stinkbugs were found on fleabane during the second generation. The results of one season's collecting, however, indicate that this plant is the most important weed host of the two stinkbugs in Virginia in June and July.

In May and June nymphs of *Euschistus servus* or *E. tristigmus*, or of both, could usually be found on common mullein, *Verbascum thapsus* L. This plant occurs over all the territory where collections were made; and although it is not a very common plant and is rather rare is some places, it may be of importance as a host of these stinkbugs in some restricted areas.

The heaviest populations of *Euschistus servus* and *E. tristigmus* that have been observed in Virginia occurred on white campion, *Lychnis alba* Mill., during May and June, when this weed was in bloom. Eggs were deposited on these plants, and the nymphs fed thereon until they reached maturity. It was the most important host of these stinkbugs in a few orchards in Albemarle County, but it was not common except in a small area around Greenwood and Crozet.

Horseweed, *Erigeron canadensis* L., is the most important weed host of the second generation of *Euschistus servus* and *E. tristigmus* in central Virginia. It is a very common weed in orchards, fence rows, and uncultivated fields throughout the state. The blooming period begins in August and extends until late September, and it is during these months that the stinkbugs are most common on this plant. The infestations on horseweed were never as heavy as those on white-top fleabane and white campion, but the abundance of the horseweed in and near orchards makes it an important source of infestation of stinkbugs on peach. This is particularly true since the second, or overwintering, brood of bugs develops on this weed.

In addition to the hosts already mentioned, nymphs of *Euschistus servus* were collected from the following plants in considerable numbers: buckhorn plantain, *Plantago lanceolata* L., oxeye daisy, *Chrysanthemum leucanthemum* L., sweet clover, *Melilotus alba* Desr., wild carrot, *Daucus carota*, L., yarrow, *Achillea millefolium* L., pigweed, *Amaranthus retroflexus* L., chicory, *Cichoria intybus* L., common plantain, *P. major* L., evening primrose, *Oenothera biennis* L., sunflower, *Helianthus annuus* L., and catnip, *Nepeta cataria* L. These hosts are arranged in the seasonal order in which the bugs were collected from them. Nymphs of *E. tristigmus* were collected in appreciable numbers from yarrow, oxeye daisy, sweet clover, snap bean, lima bean, chicory, and burdock, *Arctium minus* Bernh. No. *Euschistus* spp. eggs or nymphs were found on cowpea, soybean, vetch, crimson clover, buckwheat, or rye.

HOSTS OF TARNISHED PLANT BUG.—Tarnished plant bugs were very common on peach trees during the blooming period in 1946. They began to appear on the trees while the buds were still in the pink stage, and the population increased until the petals dropped about the last of March. At this time the population had become as high as 13 bugs per tree along the edges of some orchards. These bugs left the peach trees rather quickly after petal-fall, and by the time the shucks were splitting nearly all of them had gone. They became common on orchard weeds at this time, but no systematic collections were made from weeds until the middle of June.

During June and early July white-top fleabane, oxeye daisy, and yarrow were the favorite hosts of the tarnished plant bug, as shown by the results of the collections. These weeds were all heavily infested from their flowering period until their maturity. As the plants matured, the population of tarnished plant bug decreased, at the same time increasing on pigweed, ragweed, and lambsquarters, *Chenopodium album* L. In August, when horseweed approached its flowering stage, the infestation of tarnished plant bug increased rapidly on this host. During the latter part of August and the first half of September weeds of this species supported

a very heavy population of tarnished plant bugs, their brushlike tops literally swarming with adults and nymphs of all stages. This weed appears to be far more important than any other species as a host of the tarnished plant bug in central Virginia. In September the population of this bug began to build up on a small white aster, *Aster vimineus* Lam., which was common in many orchards.

White-top fleabane, horseweed, and *Aster vimineus* were the most important hosts of the tarnished plant bug in seasonal succession. White campion, where it was common, was almost as important as the fleabane at approximately the same time. Ragweed, *Ambrosia artemisiifolia* L., pigweed, and lambsquarters were of second rank in importance, seldom supporting as heavy infestations as the plants listed above. Pigweed, unlike the other hosts observed, seemed to be attractive to the tarnished plant bug at all stages of its growth, whereas most of the hosts were not heavily infested until they approached their flowering stage. Sweet clover was the only crop plant on which a large population of tarnished plant bug was found, although a few were collected from red clover and alfalfa. Other plants on which this bug breeds in fairly large numbers are, in seasonal order, butterfly weed, *Asclepias tuberosa* L., timothy, *Phleum pratense* L., buckhorn plantain, dock, *Rumex crispus* L., Spanish needles, *Bidens bipinnata* L., wild carrot, Canada bluegrass, *Poa compressa* L., prickly lettuce, *Lactuca scariola* L., common plantain, smartweed, *Polygonum pennsylvanicum* L., goldenrod, *Solidago* spp., evening primrose, cocklebur, *Xanthium* sp., and wormseed, *Chenopodium ambrosioides anthelminticum* L.

The infestation of tarnished plant bug usually reached its peak on a given host just after most of the flowers had opened. The population generally remained fairly stable until the seeds matured, after which it dropped rapidly. The first generation of the bugs was common on the early flowering weeds in the orchards. The population shifted to a succession of hosts throughout the season. The time of appearance of large numbers of nymphs on the different hosts suggests that most of the eggs were deposited on plants that were in flower or about ready to bloom. The most intense populations observed were on horseweed in September. This was probably due partly to the fact that the total population of the bug had reached a high point after several generations and also to the fact that other attractive hosts were not common at that season. Although one or more species of weeds appeared to be outstandingly favorite hosts at any given season, tarnished plant bugs in both nymphal and adult stages could be found on almost every species of weed that was examined. The results of the collections indicate that weeds are of much greater importance in the propagation of tarnished plant bugs than are cover crops.

SUMMARY.—Cat-facing of peaches, caused by *Euschistus* spp. and the tarnished plant bug, has been causing considerable losses in Virginia in recent years. Since these bugs do not breed on peach an attempt was made to determine what plants serve as their principal hosts. The stinkbugs of the genus *Euschistus* breed heavily on white-top fleabane, white campion, common mullein, and horseweed. The tarnished plant bug prefers as hosts white-top fleabane, oxeye daisy, white campion, horseweed, *Aster vimineus*, pigweed, ragweed, and lambsquarters, but this species breeds on almost any weed. Weeds are apparently much more important as sources of these bugs than are cover crops. It is recommended that where cultivation is not practiced weeds be kept mowed to lessen the breeding of the stinkbugs and the tarnished plant bug.—11-2-46.

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New Insecticides for Control of Pear Psylla

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For a number of years the chief method of controlling the pear psylla, *Psylla pyricola* Foerst., during the summer months has been spraying with nicotine sulfate, alone or mixed with lime or light mineral oil. Such sprays properly applied usually give good commercial control of the nymphs and when oil is included in the formulation kill large numbers of adults. However, the present shortage of nicotine and the need for even more effective materials for use in the pear psylla control program in the Pacific Northwest created a need for an evaluation of the more promising new materials against this insect. This paper summarizes results of tests conducted at Poughkeepsie, N. Y., from 1943 to 1946, with nicotine and rotenone insecticides, benzene hexachloride, hexaethyl tetraphosphate, and "piperonyl cyclohexenone" with pyrethrum.

EXPERIMENTAL METHODS.—All tests were carried on in commercial plantings of Bartlett and Kieffer pears. The sprays were applied from the ground with a single-nozzle gun with a 0.56 inch orifice and a pump having a capacity of 35 gallons per minute. Ten series of tests were conducted.

Single-tree plots, replicated two to four times, were used prior to August 1946, and 2-row plots containing three trees in each row were used without replication after that time. In the 2-row plots results were taken on the 2 middle trees in each plot.

[1] Work reported herein was conducted in cooperation with the New York State Agricultural Experiment Station in Poughkeepsie, N. Y.

Table 1.—Nymphs per spur on untreated Bartlett and Kieffer pear trees.

DATE OF TREATMENT	TEST NO.	NYMPHS PER SPUR
May 29, 1943	1	3.5
May 19, 1944	2	8.2
April 25, 1945	3	66.4
1946		
May 14	4	34.9
July 19	5	3.9
Aug. 15	6	42.7
Sept. 23	7	15.3
25	8	17.2
26	9	17.2
27	10	16.2

From 2 to 5 days after treatment, counts were made of the living nymphs present on 10 spurs taken at random from at least two trees that received each treatment. The nymphs per spur on the untreated trees that were used as checks for the different tests are shown in table 1. The per cent reduction in the number of nymphs was calculated by the usual methods. The kill of adults was obtained by counting, 1 hour after spraying, the dead adults present in rectangular white-metal pans that had been placed under the trees just prior to spraying. Each pan had an area of 3.54 square feet.

NICOTINE INSECTICIDES.—Tests were made with several standard nicotine sulfate mixtures and a processed dry concentrate containing 14 per cent of nicotine. The results are summarized in table 2.

The nicotine concentrate, especially when used with lime, compared favorably with nicotine sulfate in various standard mixtures in the control of nymphs. Neither form killed many adult psyllas.

Results obtained with the nicotine sulfate mixtures varied widely. This variation in some cases was probably due to differences in temperature, which affects the volatility and the insecticidal action of the nicotine. The best results were obtained when the temperature of the air and spray water was high. These results emphasize the need for an insecticide more consistently effective than nicotine sulfate under all conditions likely to be encountered in the control of the pear psylla.

ROTENONE-BEARING SPRAYS.—Tests were made with two rotenone-bearing materials, a ground cube root containing 5 per cent of rotenone and a commercial paste containing 50 per cent of cube root. (Table 3) Both the rotenone-bearing materials were about equivalent to nicotine in controlling the nymphs of the pear psylla. Soybean flour did not increase the effectiveness of the ground cube root. The ground cube root killed few adults. The commercial cube paste killed many more adults, especially when used with the oil. Since this paste contains oily substances, it is more effective against adults when used without mineral oil than either the

Table 2.—Tests with nicotine insecticides against pear psylla nymphs.

MATERIALS (QUANTITIES PER 100 GAL.)	PER CENT REDUCTION OF NYMPHS									
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Nicotine sulfate (40%) 1 pt. plus:										
No accessory material	95.1	97.6	95.6	95.1	61.5	97.7	51.6	—	—	0.0
Triton B-1956[1] 2 oz.	—	—	—	—	—	—	—	74.4	67.4	—
Hydrated lime 9 lb. (3 lb. in test 2)	96.5	91.5	—	95.4	—	96.5	—	—	—	—
Emulsifiable oil (60 sec. Say) 2 qt.	95.1	95.1	—	64.2	—	—	—	—	—	—
Nicotine dry concentrate (14% nicotine) 3 lb. plus:										
No accessory material	—	—	94.7	88.8	—	—	—	—	—	0.0
Hydrated lime 9 lb.	—	—	—	97.4	—	—	—	—	—	77.8

[1] A phthalic glyceryl alkyd resin.

cube powder or nicotine sulfate. The paste form is less satisfactory to handle than insecticides processed in powder or liquid form.

TESTS OF BENZENE HEXACHLORIDE.—Dustan *et al.* (1946) recently reported that benzene hexachloride was highly toxic to pear psylla nymphs in laboratory tests. At Poughkeepsie, field tests were made with a commercial wettable powder said to contain 31.6 per cent of benzene hexachloride containing 12 per cent of the gamma isomer. The finished product, then, contained 3.8 per cent of the gamma isomer (Table 4).

Benzene hexachloride was highly efficient in controlling pear psylla nymphs under orchard conditions when as little as 2 pounds of the wettable powder was used per 100 gallons. When this material was used with oil, the efficiency against nymphs continued at a high level and large numbers of adults were killed.

Unfortunately, benzene hexachloride is disagreeable to work with and sometimes causes headache. Furthermore, Kieffer pears sprayed with it on July 19 had a slightly musty taste when picked on September 26 and those sprayed on July 19 and again August 16 had a distinct bitter, musty flavor at harvest. Therefore in practical orchard spraying, it should be used early in the season. Analyses made by the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine indicated that the

Table 3.—Tests with rotenone-containing sprays against pear psylla nymphs.

MATERIALS (QUANTITIES PER 100 GAL.)	PER CENT REDUCTION OF NYMPHS					
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 9
Cube root (5% rotenone):						
1.5 lb.	—	—	92.9	—	—	—
3 lb.	100.0	—	90.4	—	—	—
1.5 lb.+soybean flour 8 oz.	—	79.3	—	—	—	—
3 lb.+soybean flour 8 oz.	—	88.2	—	—	—	—
Commercial paste (50% cube):						
1 lb.	—	—	—	54.4	—	90.7
1.5 lb.	97.7	—	—	—	—	—
1 lb.+emulsifiable oil 2 qt.	—	—	—	—	99.2	—
1.5 lb.+emulsifiable oil 2 qt.	97.7	—	—	—	—	—
1 lb.+emulsifiable oil 1 gal.	—	—	—	—	—	99.4

Table 4.—Tests with benzene hexachloride against pear psylla nymphs.

BENZENE HEXACHLORIDE (3.8% OF GAMMA ISOMER) (QUANTITIES PER 100 GAL.)	PER CENT REDUCTION OF NYMPHS		
	Test 4	Test 5	Test 10
1 lb.	—	—	93.2
2 lb.	—	—	98.1
3 lb.	—	97.4	99.4
3 lb.+emulsifiable oil 1 pt.	92.0	—	—
1 gal.	—	—	99.4

pears sprayed on July 19 carried a calculated residue of 0.95 p.p.m., of $C_6H_6Cl_6$ from total chlorine and those sprayed on July 19 and again August 16 carried a residue of 1.31 p.p.m.

HEXAETHYL TETRAPHOSPHATE.—A technical grade of hexaethyl tetraphosphate and a commercial mixture containing 50 per cent of technical hexaethyl tetraphosphate, were tested against the pear psylla in August and September 1946. The technical material was mixed in the laboratory with Triton B-1956 and in two tests xylene was added, forming an emulsion (Table 5).

Table 5.—Tests with hexaethyl tetraphosphate against pear psylla nymphs.

Materials (Quantities per 100 Gal.)	Per Cent Reduction of Nymphs	
	Test 6	Test 8
Hexaethyl tetraphosphate (technical):		
8 oz.+*Triton B-1956* 2 oz.	87.6	97.1
50%+*Triton B-1956* 10%+xylene 40%, 1 pt.	82.0	—
50%+*Triton B-1956* 5%+xylene 45%, 1 pt.	—	98.3
Commercial mixture, 1 pt.:		
No accessory material	—	98.8
Plus emulsifiable oil, 1 gal.	—	100.0

In test 6 (August 1946) the technical material, used at 8 ounces per 100 gallons in water containing 2 ounces of *Triton B-1956*, or the 50 per cent emulsified solution at the rate of 1 pint per 100 gallons, was not so effective as nicotine sulfate. In later tests carried on at lower temperatures, both mixtures, as well as a commercial 50 per cent formulation at 1 pint per 100 gallons, gave slightly better control than usually obtained with nicotine. However, the kill of adults was not great except when oil was added to the mixtures. This material, as used, did not injure pear foliage or affect the spray operators when applications were made in the usual way.

"PIPERONYL CYCLOHEXENONE" WITH PYRETHRINS.—A proprietary material reported to contain 8 per cent of "piperonyl cyclohexenone" and 0.8 per cent of pyrethrins was used in two tests at the rate of 1 and 2 pints per 100 gallons. The reduction of pear psylla nymphs with the 1-pint concentration was 89.5 per cent in test 6; with the 1-quart concentration it was 87.2 per cent in test 5, and 99.3 per cent in test 6. This material killed large numbers of adults and did not injure pear foliage.

OTHER MATERIALS.—A number of other materials were tested which were comparatively or entirely ineffective against the pear psylla when applied primarily to control the nymphs during the growing season. Such materials and the rate per 100 gallons at which they were used were as follows: DDT, 1 pound, both as a water suspension and as an emulsified solution; hydroxypentamethylflavan, 4 pounds of a 30 per cent powder; sabadilla, 5 pounds of a 50 per cent powder; a mixture containing 15 per cent of DDT plus 20 per cent of methylnaphthalenes (*Tobacine*), 1 pound; *Ryania* wood, 6 pounds; *Ryania* extract containing the equivalent of 5 pounds of *Ryania* wood, 1 quart; tank-mixed nicotine bentonite (1 pint of nicotine sulfate plus 8 pounds of Mississippi bentonite and 1 quart of soybean oil); lauryl isoquinolinium bromide (*Isothan Q 15*), 1 pint; dicyclohexylamine salt of dinitro-*o*-cyclohexylphenol (*DN-111*), 1.25 pounds; emulsifiable mineral oil, 0.5 and 1 per cent; micronized phenothiazine, 2 pounds; nicotine-antimony-sugar solutions, 2 pints; hydrated lime, 10 pounds.

SUMMARY.—A number of materials under development as insecticides in recent years have been tested in sprays under orchard conditions for control of pear psylla, *Psylla pyricola* Foerst., during the growing season. The most promising of these materials include a mixture containing 8 per cent of "piperonyl cyclohexenone" and 0.8 per cent of pyrethrins, hexaethyl tetraphosphate, cube root powder containing 5 per cent rotenone, a 50 per cent cube root paste, benzene hexachloride, and a nicotine powder containing 14 per cent of nicotine, used with hydrated lime. Benzene hexachloride imparted a musty flavor to the fruit, and therefore it should be applied early in the season. Materials that were comparatively or entirely ineffective included DDT, tank-mixed nicotine bentonite, *Ryania*, sabadilla, emulsifiable mineral oil, dicyclohexylamine salt of dinitro-*o*-cyclohexylphenol, lauryl isoquinolinium bromide, and phenothiazine.—11-22-46.

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Recent Advances in Control of Ornamental and Shade Tree Insects

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Since my report read to this group on November 29, 1945, on "New Developments in Shade Tree Insect Control" considerable new information on the new insecticides for the control of ornamental and shade tree insects has been obtained. These will be discussed under the headings of: (1) Resin Emulsion of Pyrethrum and Rotenone (2) DDT and (3) Benzene Hexachloride.

RESIN EMULSION OF PYRETHRUM AND ROTENONE.[1]—A relatively new resin emulsion of pyrethrum and rotenone has been tested both in the Laboratory and in field applications since 1938.[1] Its value in the ornamental field lies in its safety to plant life, effectiveness in controlling a variety of both chewing and sucking insect pests as well as red spiders, and above all, in that it leaves no unsightly residue to mar the appearance of the green leaf or tender blossoms.

During the spring and early summer of 1946 an experiment was conducted to test the effectiveness and practicability of blanket sprays of this resin emulsion at the dosage of 1 to 100 over the entire shade tree, shrubbery, and flower bed plantings around a house. Four applications were made by means of a power spray rig, the first on May 22nd, the second on July 2nd, the third on July 12th and the fourth on July 17th. Careful records were kept on the control of a number of insect pests of trees, shrubs, vines and flowers and vegetable gardens Excellent control was obtained of the following insects:

European apple sawfly, *Hoplocampa testudinea* Klug, on astrakhan apple.
Apple maggot fly, *Rhagoletis pomonella* Walsh, on astrakhan apple.
Rosy apple aphid, *Anuraphis roseus* (Baker), on Rhode Island Greening.
Apple red bug, *Lygidea mendax* Reut. on apple.
European red mite, *Paratetranychus pilosus* (C. & F.), on apple and cherry.
Garden red spider, *Tetranychus bimaculatus* Harvey, on phlox.
Spirea aphid, *Aphis spiraecola* Patch, on Bridal Wreath.
Bean aphid, *Aphis rumicis* L., on dahlia and nasturtium.
European rose slug, *Caliroa aethiops* (F.), on rose.
Rose aphid, *Macrosiphum rosae* (L.) on rose.
Rose leafhopper, *Typhlocyba rosae* (L.), on rose.
Imported currant worm, *Pteronidea ribesii* (Scop.) on gooseberry.
Potato leafhopper, *Empoasca fabae* (Harr.) on dahlia.

The Japanese beetle, *Popillia japonica* Newn., was not killed to any extent by this treatment but was so disturbed that it forsook sprayed plants for a period of several days after each application. Hand sprayers, as well as power sprayer, applications on adjacent areas, using *Styx*[2] at the strength of 1 to 15, killed many of the Japanese beetles.

The Japanese beetle, by the way, staged a partial comeback in 1946 in North Stamford, Conn. The peak year of adult abundance of 1943 was followed by a great decline in numbers during 1944 and 1945 due largely to the drought conditions of that period. *Popillia japonica* has furthermore been successively later in reaching peak of seasonal abundance. In 1946, the maximum of beetle flight and feeding did not come until the third week in August in our particular area. We are now beginning to have some benefit, in so far as grub damage is concerned, from the inoculation with milky disease spores which was done on June 3, 1941. In the small area of the lawn where the inoculation was made, there was very little grub feeding this year. There was, however, little reduction of grubs on the lawn 200 feet from the inoculated area.

A blanket application of a Japanese beetle repellent spray (a finely powdered amorphous diatomaceous silica:[3] 5 lbs. to 100 gal. plus an alkyd resin binder used in cold water paints[4] at 1 lb. to 100 gals.) over a considerable area at North Stamford, Connecticut, applied by power sprayer on July 13, 1946, gave satisfactory repellency, until new growth appeared in about 2 weeks time, on the more beetle-susceptible trees. Spot applications of a water-dispersible DDT powder[5] at 1 lb. actual DDT to 100 gals. cleaned up these foci of infestation for about 2 weeks longer.

[1] Eastern Branch Program.

[2] *Styx*. Bartlett Tree Expert Company, Stamford, Conn.
[3] *Celite* 394-B. Johns-Manville Company, 22 East 40th Street, New York City.
[4] *Aquaplex 8-6*. Resinous Products and Chemical Company, Washington Square, Phila., Pa.
[5] *Deenate 25W*. DuPont Chemical Company, Wilmington, Delaware.

No infestation of the codling moth, *Carpocapsa pomonella* (L.), was present on the apple trees this season but this insect has not been a problem on our apple plantings for the past 10 years. The fall cankerworm, *Alsophila pometaria* (Harr.), was conspicuous by its absence throughout this area, both sprayed and unsprayed, in 1946.

A large series of applications of 10 per cent DDT dissolved in xylene and diluted with kerosene were made in 1946, using a mist power blower for atomizing the insecticide.

THE GYPSY MOTH, *Porthetria dispar* (L.).—Power atomizations of DDT following the method developed by the U. S Bureau of Entomology and Plant Quarantine at the Gypsy Moth Station at Greenfield, Massachusetts, were outstanding for the control of the gypsy moth. Approximately 2000 lbs. of DDT crystals in solution were applied in Massachusetts in 1946 for gypsy moth control by means of two power atomizers. The excellent kill of the small caterpillars before foliage damage is caused and the consequent protection of the treated trees, shrubs and plants throughout the entire season makes the DDT method of gypsy moth control far superior to other methods practiced while the speed of application and reduction of labor costs make it the quickest and cheapest method of control where considerable areas are concerned.

The most important item favoring DDT for gypsy moth control is the fact that, contrary to the case of most insect pests, it is not necessary to cover the entire tree and foliage with DDT to control the gypsy moth inasmuch as the wandering habits of the young caterpillars cause them to walk through a film of the poison if the trunk of the tree is well covered with DDT. We do not have to wait for the caterpillars to feed on the foliage to be poisoned, as in the case of arsenate of lead.

THE BAGWORM, *Thyridopteryx ephemeraeformis* (Haw.).—Concentrated sprays and dusts of a water dispersible DDT powder[1] were applied by a mist power blower[2] to a variety of trees and shrubs in June 1946, at Cynwyd, Pennsylvania, to determine its effect on the bagworm. No control was obtained, indicating that the bagworm is one of those insects which is resistant to DDT.

Table 1.—Laboratory tests with benzene hexachloride for fall webworm (half to three-quarter grown) on persimmon; treated September 12, 1946.

I. TREATED	DEAD	ALIVE	CONDITION OF FOLIAGE
24 hours	40	116	No feeding
48 hours	125	71	No feeding
72 hours	141	15	No feeding
96 hours	156	0	No feeding
II. CHECK (UNTREATED)			
24 hours	11	189	10 per cent defoliation
48 hours	17	183	25 per cent defoliation
72 hours	removed		100 per cent defoliation
96 hours	—	—	

POLLINATING INSECTS.—On April 30, 1946, in North Stamford, DDT was applied by means of a turbine blower in both solution and powder form, more to experiment with the handling of the machine than to control any particular insect. There was no infestation of fall cankerworm to begin with and the tent caterpillar had already been controlled by an application of wettable sulfur[3] at 8 lbs. to 100 gallons on April 12, 1946. Observations following the application revealed that the blanket covering of the area with DDT did infinitely more harm than good in the absence of any destructive insect at that particular time. Pollinating insects such as Halictidae, Andrenidae, Apidae, Syrphidae and Tachinidae were slaughtered in great numbers by the DDT application on certain varieties of apple, barberry, violets and other shrubs and flowers then in blossom. Taken in conjunction with the windy, rainy weather this so interfered with the set of fruit on certain varieties of apple that no crop was obtained in 1946 on these particular varieties.

THE ELM LEAF BEETLE, *Galerucella xanthomelaena* (Schr.).—The elm leaf beetle was unusually abundant and destructive in the northeastern states in both 1945 and 1946. On July 6, 1945 eight good sized elms were sprayed on one estate in Greenwich, Connecticut, with a water dispersible DDT powder[4] at the rate of 1 lb. of actual DDT to 100 gals.

[1] *Deenate 50W.* DuPont Chemical Company, Wilmington, Delaware.
[2] *Buffalo Turbine Blower.* Buffalo Turbine Agricultural & Equipment Company, Gowanada, N. Y.
[3] *Sulforon.* DuPont Chemical Company, Wilmington, Delaware.
[4] *Deenate 25W.* DuPont Chemical Company, Wilmington, Delaware.

by means of a power spray rig. The insect was in the larval stage about three-quarters or more grown at the time of application. The infestation was so completely controlled by the one spraying that an application in 1946 was not necessary, the trees remaining free from attack this entire season although unsprayed trees in the general area were defoliated in 1946. The importance of elm leaf beetle control during these times of Dutch elm disease visitation cannot be over-emphasized.

This is, of course, an isolated instance and DDT should not be recommended for control of elm leaf beetle on the basis of this one experiment. Suffice it to say that experiments will be conducted on this problem another season.

THE ORIENTAL FRUIT MOTH, *Grapholitha molesta* Busck.—Further observations on oriental fruit moth control on the 15 peach trees growing on the experimental grounds at North Stamford, Connecticut, in 1946 showed that this fruit pest was brought under practical control by the parasites liberated on June 13th from the Connecticut Agricultural Experiment Station. As a partial result of keeping DDT off the trees this season, we had the cleanest crop of peaches in 1946 that we have ever experienced. We are ascribing the excellence of the fruit, among other factors, to exceptionally good control of brown rot and peach scab fungi by means of sprays of 2-3 dichloro-1, 4-naphthoquinone[1] which was applied during the latter part of the season.

[1] *Phygon*. United States Rubber Company, Naugatuck, Conn.

BENZENE HEXACHLORIDE.—Benzene hexachloride[2] applied in 1946 by hand duster to the following trees and shrubs resulted in no foliage injury:

Acer ginnala
Acer pennsylvanicum
Acer rubrum
Acer tataricum
Aesculus glabra
Amelanchier canadensis
Betula lenta
Betula nigra
Betula pendula
Castanea sp.
Celtis occidentalis
Cercis canadensis
Cornus florida
Crataegus spp.
Diospyros virginiana
Euonymus europaea
Fagus americana
Fagus sylvatica
Gleditsia triacanthos
Gymnocladus dioica
Holesia monticola
Juglans nigra
Juglans sieboldiana cordiformis
Malus halliana
Malus pumila
Nyssa sylvatica
Ostrya carpinifolia
Ostrya virginiana
Prunus avium
Prunus domestica
Prunus persica
Pyrus communis
Quercus alba
Quercus prinus
Quercus stellata
Salix lucida
Salix nigra
Salix vitellina
Sorbus americana
Ulmus pumila

Complete control of the following was obtained: Woolly aphid, *Eriosoma crataegi* (Oestl.), on hawthorn; Japanese beetle on Siberian elm for a 2 week period; and fall webworm, *Hyphantria cunea* (Drury), on apple. Very little control of the apple leafhopper, *Empoasca maligna* Walsh, was apparent on the latter tree 3 weeks after application. Unfavorable factors in the use of benzene hexachloride appeared to be the unsightly residue left on the foliage as well as the odor which resembles that of musty, moldy straw and which persists for a fortnight or more, depending on weather conditions.—11-21-46

[2] *Sizide 10% (1% gamma)*. Commercial Solvents Corporation, 17 East 42nd Street, New York City.

STATISTICAL SUMMER SESSION

Statisticians and those interested in statistics from the United States and foreign countries will convene at Virginia Polytechnic Institute, Blacksburg, Virginia, for the Statistical Summer Session, August 5 to September 5.

This Summer Statistical Session is being sponsored jointly by Virginia Polytechnic Institute, University of North Carolina, University of Michigan, Iowa State College, and the Federal Bureau of Agricultural Economics.

The faculty will consist of: Walter A. Hendricks, B.A.E., U.S.D.A.; Renis Likert, University of Michigan; H. L. Lucas, University of North Carolina; Maurice G. Kendall, England; George W. Snedecor, Iowa State College; Frank Yates, Rothamsted Experiment Station, England; Earl E. Houseman, B.A.E., U.S.D.A.; Raymond J. Jessen, Iowa State College, and Boyd Harshbarger, Virginia Polytechnic Institute.

The following courses will be offered for credit: Engineering Statistics; Statistical Methods; Design of Animal Experiments; Schedule Design and Interview Techniques for Sample Surveys; Sampling Design and Analysis; Mathematical Theory of Sampling; Seminar; Mathematical Statistics, and Experimental Design.

In addition to the faculty, probable Seminar speakers are: W. F. Callendar, W. G. Cochran, Miss Gertrude M. Cox, W. E. Deming, George Gallup, Maurice Hansen, Harold Hotelling, Arnold King, and Charles F. Sarle.

Inquiries regarding the Summer Session should be addressed to Boyd Harshbarger, Professor of Statistics, Statistical Summer Session, Virginia Polytechnic Institute, Blacksburg, Virginia.

Treatment of Aeroplanes to Prevent Accidental Transportation of Japanese Beetles

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During the recent war period it was difficult to prevent adult Japanese beetles (*Papillia japonica* Newm.) from being accidentally transported in military aircraft to noninfested areas, in certain instances where airports were in a congregation zone of this insect. Army and Navy officials cooperated to the fullest extent to prevent such occurrences, but preventive measures consisted solely in keeping plane cabins closed while on the ground or in hand picking the beetles out of the planes. In 1945 tests were begun in an attempt to perform the task by the use of insecticides. This report covers the tests made from May to August 1945.

It was considered that destruction of beetles in plane cabins could best be accomplished by use of either aerosols or DDT residual dusts or sprays, or a combination of the two. A number of laboratory tests were made at Beltsville, Md., and Trenton, N.J., to determine the toxicity to adult Japanese beetles of various aerosol formulas and residues of DDT applied as dusts or sprays. Later the efficiency of aerosols was tested in several types of military aircraft at airfields near Washington, D.C., and New York City.

Tests with Aerosols.—Laboratory tests were made in an improvised 225 cubic foot chamber closely resembling a standard Peet-Grady chamber. Six aerosol formulas were selected for testing including ones with DDT and pyrethrum in combination and alone. These formulas are designated by number and appear in other publications under the same number. The following shows their percentage composition:

Formula		Per Cent
199	Pyrethrum extract (20 per cent pyrethrins)	2
	DDT	3
	APS 202 (an aromatic petroleum fraction)	15
	Freon-12 (dichlorodifluoromethane)	80
179	Pyrethrum extract (20 per cent pyrethrins)	2
	DDT	3
	Cyclohexanone	5
	Lubricating oil SAE 30	5
	Freon-12	85
320	Pyrethrum extract (20 per cent pyrethrins)	4
	DDT	6
	APS 202	14
	Propylene oxide	6
	Freon-12	70
322	DDT	6
	APS 202	14
	Propylene oxide	6
	Freon-12	74
324	Pyrethrum extract (20 per cent pyrethrins)	2
	DDT	6
	D & O 312 (a piperonyl cyclohexenone)	3
	APS 202	14
	Propylene oxide	5
	Freon-12	70
215	Pyrethrum extract (20 per cent pyrethrins)	2
	Sesame oil	8
	Freon-12	90

Adult beetles freshly collected from natural hosts were used in all tests. The beetles were liberated in the chamber, and exposed to the aerosol for 15 minutes, after which they were removed and placed in cardboard containers for observation. The aerosols were applied from a special laboratory dispenser equipped with a capillary nozzle 0.048 inch in diameter. Fresh containers were used for each sample. After each test the chamber walls were washed with acetone and new paper was placed on the floor. Approximately 7000 beetles were used in the tests. Early and late in the season the number of beetles used per test was smaller than the number used during the period when they were more plentiful. From 50 to 100 beetles were held for checks. If all beetles used in a single day's tests were from the same lot, only one check was held for all tests, but if the beetles used were from more than one lot a similar number of check beetles was taken from each lot.

The results of the tests are summarized in table 1. Although complete mortality

[1] Considerable assistance was rendered by E. R. McGovran and John H. Fales of the Beltsville Laboratory of the Bureau, by staff members of the Orlando, Fla., laboratory, and by members of the Division of Japanese Beetle Control. Acknowledgement is also made of the fine cooperation of various Army and Navy officials in arranging for use of military aircraft.

Table 1.—Accumulative mortality of adult Japanese beetles produced by 14-minute exposures to various aerosols containing DDT and pyrethrum. Except as otherwise indicated, all tests are averages of 3 replications using 20 to 50 beetles in each.

Formula[1]	Dosage of Aerosol (Grams per 1000 Cu. Ft.)	Per Cent Mortality of Adults after Indicated Number of Days					
		1	2	3	4	5	6
199[1]	176	94	100				
	88	71	100				
	66	75	100				
	52.8	55	100				
	44	23	91	100			
	35.2	40	100				
	26.4	35	100				
	17.6	86	98	100			
	8.8	65	100				
	6.6	60	93	95	98	100	
	4.4	35	56	62	65	68	82
	None	0	0	0	0	2	6[2]
179	176	100					
	88	55	100				
	66	65	100				
	52.8	46	98	100			
	44	18	68	96	100		
	35.2	40	98	100			
	26.4	27	87	100			
	17.6	78	100				
	8.8	54	94	100			
	6.6	48	98	100			
	4.4	48	69	80	87	88	92
	None	0	0	0	0	2	6[2]
320	176	75	100				
	88	80	100				
	66	60	100				
	52.8	60	100				
	44	25	86	100			
	35.2	76	100				
	26.4	25	97	100			
	17.6	91	100				
	8.8	60	94	100			
	6.6	84	100				
	4.4	44	70	76	86	86	91
	None	0	0	0	0	2	6[2]
322	176	80	100				
	88	91	100				
	66	52	100				
	52.8	81	100				
	44	15	81	100			
	35.2	70	100				
	26.4	40	92	100			
	17.6	93	97	100			
	8.8	67	100				
	6.6	90	98	100			
	4.4	70	96	98	98	98	98
	None	0	0	0	0	2	6[2]
324	176	65	100				
	88	78	98	100			
	66	52	100				
	52.8	45	100				
	44	10	65	96	100		
	35.2	60	98	100			
	26.4	35	97	100			
	17.6	93	100				
	8.8	50	96	100			
	6.6	84	100				
	4.4	60	92	94	96	96	96
	None	0	0	0	0	2	6[2]
215[3]	176	14	42	74	84	90	90
	88	12	56	60	78	88	88
	66	8	32	56	58	70	77
	52.8	8	36	48	48	52	54[4]
	44	4	20	34	38	38	38
	35.2	6	24	24	42	48	48
	26.4	4	12	16	18	24	26
	17.6	6	16	38	46	46	46
	8.8	0	4	14	22	32	32
	None	0	0	0	0	8	8[5]

[1] 20 to 100 beetles.
[2] 22 after 8 days.
[3] 9 replications, 50 beetles each.
[4] 86 after 9 days.
[5] 18 after 9 days.

was obtained only when aerosols containing DDT were used, in no instance did it occur in 24 hours. A dosage as small as 6.6 grams per 1000 cubic feet of aerosol containing 3 per cent of DDT was as effective as a dosage as large as 176 grams containing 6 per cent of DDT. Likewise it was observed that all dosages of aerosols containing DDT immediately inactivated the beetles. Some flight activity occurred at the beginning of an aerosol application, but all beetles were soon on their backs. Death was recorded only when an individual failed to respond in any manner to artificial stimuli. In all DDT applications the beetles remained moribund until death or the end of the experiment, refusing all food and apparently having no coordination of movement. With pyrethrum alone (formula 215) those beetles not succumbing began to feed after one or more days and appeared normal in behavior.

On the basis of results given in table 1 formula 199 was selected for further testing. The effect of the length of exposure to the aerosol was tested with this formula at a dosage of 8.8 grams of aerosol per 1000 cubic feet. These results are given in table 2. They show that a lethal dosage is deposited on the beetles at the time the aerosol is first applied.

Table 2.—Accumulative mortality of adult Japanese beetles resulting from various periods of exposure to aerosols at a dosage of 8.8 grams of formula 199 per 1000 cubic feet. All tests are averages of 3 replications using 50 beetles in each.

Exposure[1]	Per Cent Mortality of Adults after—				
	1 day	2 days	3 days	4 days	5 days
Minutes					
30	58	91	95	100	
10	65	94	99	99	100
2	66	95	98	100	
1	65	94	95	100	
Seconds					
30	74	98	100		
10	51	86	97	100	
5	67	92	96	100	
None	0.13	0.1	0.2	4	

[1] Short exposures were obtained by quickly removing the paper floor covering upon which the beetles had fallen.

Tests with DDT residues.—Laboratory tests were also made to study the effectiveness of DDT residues against adult beetles. Unpainted plywood and corrugated rubber matting were selected as representing the floor surfaces in military aircraft.

DDT in dust and spray form was applied to sections of the two surface types. The following formulations were used:

	Per Cent
Dust	
DDT	10
Talc	90
Oil spray *CS327*	
DDT	15
APS 202	50
Deobase[1]	35
Oil spray *CS328*	
DDT	15
Orthodichlorobenzene	40
Deobase	45
Emulsion	
DDT	22.5
Triton	10
APS 202	67.5

[1] Deodorized kerosene.

The dust was applied as a fine coating. The sprays were applied with a compressed-air sprayer in small quantities just enough to wet the surfaces of the sections. The emulsion stock solution was diluted with 3 parts of water before application. In each test adult beetles were confined on the treated surfaces for 30 minutes and then removed to cardboard cages for observation. At intervals fresh lots of beetles were confined on exactly the same areas and also observed. The results are given in table 3. Check samples exposed to untreated surfaces showed an average mortality of less than 4 per cent.

Table 3.—Accumulative mortality of adult Japanese beetles resulting from their confinement on wood and rubber surfaces which had been dusted or sprayed with DDT. Twenty to 100 beetles per test.

Type of Application	Age of Residue (days)	Mortality of Adults Confined on Plywood (Per cent)			Mortality of Adults Confined on Rubber Matting (Per cent)		
		1 day	2 days	3 days	1 day	2 days	3 days
Dust	1	20	90	100	30	100	
	6	20	80	100	25	85	100
	12	95	100		80	100	
	30	64	100		36	92	100
	60	58	92	100			
	66	70	93	100			
	81	33	100				
	96	50	100				
	114	100					
Oil spray CS327	1	85	100		10	30	30
	15	100			20	44	74
	20	48	100		0	16	16
	48	68	100				
	71	70	100				
	86	55	100				
	103	80	100				
Oil spray CS328	1	95	100		0	0	10
	15	100			24	32	66
	20	24	100		0	0	0
	48	48	100				
	71	18	100				
	86	75	100				
	103	90	100				
Emulsion	1	95	100		25	95	100
	11	100			32	40	82
	16	60	100		0	0	0
	44	55	100				
	66	75	100				
	82	65	100				
	100	90	100				

All three sprays and the dust gave complete mortality of adults confined on plywood after more than 100 days. Since each new lot of beetles was confined on the same area as the previous lots, some residue was removed each time. Only the dust remained effective on the corrugated rubber surface. The sprays were apparently absorbed by the rubber.

Residues from aerosols were tested by hanging sections of plywood and rubber in the exposure chamber during aerosol applications, and later confining beetles on their surfaces for 30 minutes as was done in the other residue tests. Residues from aerosol dosages of 44 and 66 grams per 1000 cubic feet, of formulas 322 and 199, were not toxic, but an additional exposure to a dosage of 88 grams produced a toxic residue which remained effective for 98 days. The results of these tests are given in table 4. It would appear that repeated applications of an aerosol would

Table 4.—Accumulative mortality of Japanese beetle adults when confined for 30 minutes on plywood and rubber sections hung in aerosol concentrations totaling 198 grams per 1000 cubic feet. 20 to 100 beetles per test.

Aerosol Formula	Age of Residue (days)	Mortality of Adults Confined on Plywood— 1 day	2 days	3 days	4 days	Mortality of Adults Confined on Rubber Matting— 1 day	2 days	3 days	4 days
322	1	50	90	100		30	30	50	50
	13	68	100			0	0	0	0
	45	22	100			0	0	0	0
	64	12	98	100					
	82	55	100						
	98	80	100						
199	1	30	80	90	100	30	30	30	36
	13[1]	3	18	48	48	0	0	4	4
	64	8	70	100		0	0	8	8
	82	15	80	100					
	98	90	100						

[1] Cool and rainy day, very little beetle activity.

eventually build up a toxic residue on wooden surfaces.

TREATMENT OF PLANES.—Through the courtesy of Army and Navy officials, 30 tests were made in military aircraft. The aerosols were applied from proprietary 5-pound dispensers that had a discharge rate of 1.5 grams per second. After each treatment the nozzle of the dispenser was removed and thoroughly cleaned with acetone. At frequent intervals the bomb was weighed, the discharge timed, and the bomb reweighed to check the rate of discharge. Beetles were liberated in the cabins of planes, and recaptured after a 15-minute exposure to an aerosol. From 100 to 200 beetles were used per test, and an average of 80 per cent of them were recovered. Check mortality was under 4 per cent.

The tests were made under various conditions and in planes with varying degrees of tightness. One test was made in flight, the remainder on the ground. Some were made in hangars, others on air fields with wind movement from nil to considerable.

The results are tabulated in table 5. In all instances complete mortality was obtained of the beetles recovered from the plane cabins. All beetles were moribund when recovered, and all refused to feed during the period of observation.

SUMMARY.—Tests were made in the laboratory and in various types of military aircraft to determine whether aerosols or DDT residues could be used to prevent accidental transportation of Jap-

Table 5.—Accumulative mortality of adult Japanese beetles resulting from 15-minute exposures to various dosages of aerosol formula 199, applied in military aircraft.

Model of Aeroplane	Dosage of Aerosol (Grams per 1000 Cu. Ft.)	Mortality of Adults after— 1 day	2 days	3 days	4 days
C 47[1]	50	92	100		
	50	86	100		
	33	89	100		
	16	86	100		
C 117	25	86	100		
C 45	30	88	100		
	15	96	100		
	33	100			
	7.5	96	100		
B 25	15	84	100		
	40	60	100		
	15	70	98	100	
	10	82	100		
	10	60	97	98	100
	15	67	100		
	15	97	100		
	15	80	98	100	
	15	98	100		
B 24	15	50	97	100	
	25	60	98	100	
	45	50	88	99	100
	30	83	100		
AT 11	15	89	100		
	30	91	100		
A 26	15	79	100		
	20	69	88	100	
GB 2	20	65	95	100	
JRF 5	20	82	100		
R 505	20	70	91	100	
JBB 4	20	62	100		

[1] Plane was treated while cruising at 2000 feet elevation with air vents open.

anese beetles *Popillia japonica* Newm. in aeroplanes. Six aerosol formulas containing DDT, pyrethrum, or combinations of the two were tested in the laboratory. Complete mortality was obtained only with formulas containing DDT, but in no instance did it occur in 24 hours. A dosage as low as 6.6 grams per 1000 cubic feet of aerosol containing 3 per cent of DDT was as effective as a dosage as large as 176 grams containing 6 per cent of DDT. All aerosols containing DDT immediately inactivated the beetles, which remained moribund until death, refusing all food and apparently having no coordination of movement. Pyrethrum aerosols did not cause complete mortality, and those beetles not succumbing began to feed after one or more days and appeared normal in behavior. Tests with one formula in which beetles were exposed for various periods to 8.8 grams per 1000 cubic feet of a 3 per cent DDT aerosol resulted in complete mortality in all exposures between 30 minutes and 5 seconds.

Laboratory tests with DDT residues on sections of unpainted plywood and corrugated rubber matting, in which lots of beetles were caged for 30 minutes on the residues after various intervals of aging, resulted in complete mortality of adults confined on plywood after more than 100 days. Only dusts were effective on the rubber matting, sprays apparently being absorbed. Plywood sections hung in consecutive aerosol concentrations totaling 198 grams per 1000 cubic feet were coated with residues toxic for 98 days to adults confined on them, but rubber matting soon lost any toxic residue.

Thirty tests in 11 types of military aircraft, under various conditions, caused complete mortality of free-flying adults with dosages from 7.5 to 50 grams of 3 per cent DDT aerosol.—12-11-46.

Biological Characteristics of Laboratory-Reared *Aëdes atropalpus*

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Aëdes (*Finlaya*) *atropalpus* (Coq.) is a mosquito found in Southern Canada, the United States, Mexico, and Central America. Carpenter *et al.* (1946), in reviewing this distribution, list 22 states in the United States. The larvae breed in rock-holes along rivers and streams. The females have been described as "readily" biting by Matheson (1944). In the laboratory, the species has transmitted the eastern strain of equine encephalomyelitis (Davis 1940) and the avian malarial parasite, *Plasmodium gallinaceum* (Trembley 1946).

Howard *et al.* (1912) reported, "One of us (Dyar) reared two successive generations of *Aëdes atropalpus* in captivity by feeding the adults upon sugar and water." This brief reference was apparently overlooked until recently when observations on the *A. atropalpus* bred in this laboratory revealed that a large proportion of the females, although denied access to blood, deposit viable eggs. This was true even for individuals given no food after the larval stage. A colony in which adults have been fed only dextrose solutions has continued for over a year, and is now in its twenty-sixth generation. This paper presents information on the duration of the developmental periods, and compares the responses of the individuals from the colony offered blood meals with those from the colony denied blood.

Ovulation responses of mosquitoes have been studied by many investigators. "Autogeny" was used by Roubaud (1929) to denote that characteristic which allows unfed females to deposit viable eggs. The ability to reproduce lies within the insect itself; the only nourishment available to the adults is that derived during their larval period. The term has since been used loosely to refer to the ability of mosquitoes to oviposit without blood meals. Roubaud (1933) differentiated the distinct races *Culex pipiens pipiens* and *C. p. autogenicus*. Subsequently, these races have been reported from various localities throughout the world; an autogenous colony in this country was described by Richards (1941). Autogeny was demon-

strated in *Aëdes concolor* Taylor by Woodhill (1936) and in *Theobaldia subochrea* Edw. by Marshall & Staley (1936). Markovich (1936) reported autogeny in *Anopheles claviger* Mg. (=*bifurcatus* auct.) in North Caucasus. *Aëdes albopictus* (Skuse)

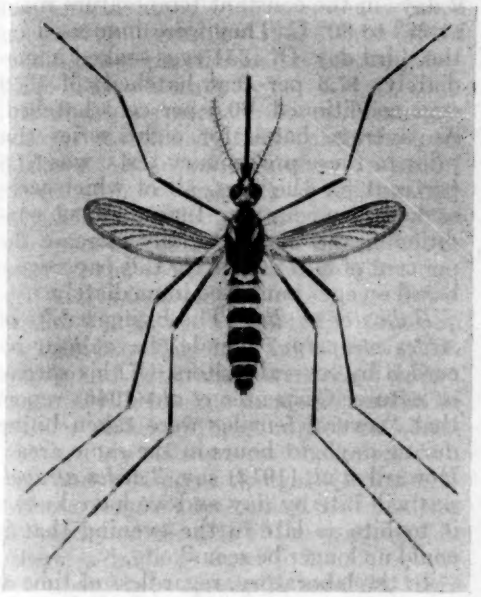

FIG. 1.—*Aëdes atropalpus* female.

(undername of *Stegomyia scutellaris*) deposited viable eggs when Sen (1917) fed the females milk and sugar, peptone and sugar, and sugar alone. Fielding (1919) fed *Aëdes aegypti* (L.) many foods other than blood, but only those females fed peptone and sugar deposited viable eggs. In the Culicinae, or true mosquitoes, the Megarhinini are furnished with a semiflexible proboscis suited only for flower-feeding. According to Edwards (1932), the genus *Harpogomyia* feeds on the regurgitated stomach contents of the ant *Crematogaster* sp.

There are undoubtedly other mosquitoes which do not require blood for the continuation of their life-cycles, but autogeny in recorded life-histories is the exception rather than the rule.

MATERIALS AND METHODS.—*Origin of colonies.*—The original colony was established in October 1944 from immature forms taken along the Potomac River at Chain Bridge, D. C. On September 29, 1945, a "special" colony was established from the original group. This colony was denied access to blood but eggs for the twenty-sixth generation were deposited on October 29, 1946.

Rearing procedures.—Rearing procedures for the larvae of both colonies are the same. In the beginning, tap-water was used and the larvae fed ground dog food and oats (Trembley 1945). Later, distilled water was substituted, with a diet of ground dog food supplemented by yeast and brain-heart infusion. For ordinary rearing purposes larvae were not counted out, nor the food measured; this is a "random" diet. For certain of the controlled experiments, newly-hatched larvae were allotted, 100 to a 15 by 9 by 2 inch developing tray, and fed according to a schedule based on one recommended for *Anopheles quadrimaculatus* by Heal & Pergrin (1945). The feeding schedule for each pan of larvae follows:

Day 1—25 mg. ground *Purina* dog food; 50 mg. Brewer's yeast; 50 mg. *Difco* brain-heart infusion.
Day 2—100 mg. dog food.
Day 3—No feeding.
Day 4—200 mg. dog food.
Day 5—300 mg. dog food.
Day 6—200 mg. dog food.

This diet is usually satisfactory at temperatures ranging from 26° to 30° C., and maintained generally between 27° and 28° C.

Adults of both colonies (except those placed in the constant-temperature room for controlled experiments) are kept in a room where the temperature has ranged from 21° to 30° C., and the relative humidity kept high by means of damp towels placed over the cages.

Adults of the general colony are kept in a screened cage, about 2 by 2 by 2 feet. They are offered blood at approximately 2-week intervals; and a pledget of cellucotton soaked in a 10 per cent dextrose solution is always available. Adults of the special colony are kept in a similar cage or one 10 by 10 by 15 inches. They are not allowed access to blood, and are fed only the dextrose solution on cotton. For controlled experiments, lantern globe containers, are used for individual and paired adults of both colonies; and they are kept in the constant temperature room at 28° to 30° C. and a relative humidity of about 80 per cent.

HABITS AND LIFE HISTORY.—*Preliminary experiments.*—In order to determine the relative importance of some of the variables that might require control, 4 preliminary experiments were performed.

1. The effect of larval feeding on oviposition was noted. Two lots, 25 females, emerging from larvae reared on random diets were compared with 2 lots, 24 females, from larvae reared on measured diets. In the first group, 23 females laid a total of 2527 eggs, of which 57.7 per cent hatched. In the second group, 17 females laid 2024 eggs of which 58.2 per cent hatched. The responses of these groups were similar to each other, and to those of a group of adults reared from larvae fed on cut oats and ground dog food. Apparently, unmeasured larval diets are satisfactory if they furnish sufficient nourishment for development to the adult stage.

2. The comparative effects of cage size on the life processes of the species were observed. Screened cages, about 10 by 10 by 15 inches, and lantern globe containers, were used. Each container held a male and a female mosquito. Thirteen of the 16 females in the cages oviposited; 12 of these 13 laid eggs which hatched. In the lantern globes, 10 of the 11 females oviposited, and all 10 of these laid eggs which hatched. Females in the cages deposited 1197 eggs, or an average of 92.1 per female; and 635, or 53.8 per cent hatched. In the lantern globes, the females deposited 950 eggs, or 95.0 per female; and 652, or 68.6 per cent hatched.

3. The effect of mating on oviposition was studied. Females confined in cages with 5 males per female showed the same proportion not ovipositing as those furnished only one male. Of the 14 females in the former group, 5 failed to oviposit; of the 14 in the latter, only 1 female failed to oviposit. The former laid 793 eggs of which 59.3 per cent hatched, whereas the latter laid 1577 with 51.1 per cent hatching.

4. The effect of "conditioning" on the hatching of the eggs was observed. Three successive series of tests were run. In each test, each filter paper containing eggs was removed on the morning following oviposition, and was cut so that the number of eggs was equally divided. One half was immersed immediately, and the other half "conditioned," or allowed to dry slowly before being immersed. In the first series, the eggs were conditioned by allowing the papers to remain on moist pads for 2 days before being dried. This method was discontinued, because most of the eggs began to hatch while on the pads. In the 2 subsequent series, the eggs were conditioned by removing the papers from the moist pads and drying them for 2 days in the constant temperature room at 28° to 30° C. They were immersed on the third day. Of 1351 eggs soaked immediately, 47.3 per cent hatched; of 1359 eggs conditioned, 60.4 per cent hatched. An average hatch for eight series run prior to these preliminary tests, was 57.8 per cent for the eggs, all of which were soaked immediately. Inasmuch as conditioning did not materially increase the per cent of hatch, data for this paper were based on eggs immersed immediately.

Habits of adults.—The biting habits of *Aëdes atropalpus* females have been recorded by several writers. Of this species in nature, Carpenter *et al.* (1946) report that "several females were taken biting during daylight hours in the same area." Howard *et al.* (1912) say, "*Aëdes atropalpus* will bite by day and we have known it to bite so late in the evening that it could no longer be seen."

In the laboratory, regardless of time of day, or intensity or color of the light, only a small proportion of the females will bite; and biting takes place readily only when a considerable period of time has elapsed after emergence. In 68 females observed, this time ranged from 12 to 22 days. After this time has elapsed, approximately 5 per cent of these older females will feed immediately when offered blood; more may be induced to feed by isolating individuals and placing them in direct contact with the host. Forty females and 40 males were allowed to emerge in a cage, and an insectary worker held her arm in the cage every other day as long as any female mosquito survived. During that time, only 2 females alighted on the arm and engorged, one on the fifteenth day and one on the nineteenth day. Twenty-eight females, each paired with a male in a lantern globe container, were offered blood meals at intervals of from 1 to 3 days. One fed readily on the twenty-first day. One was induced to feed on the thirteenth day, 3 on the twenty-first, 5 on the twenty-second, and 2 on the twenty-third.

In transmission studies, Davis (1940) used mouse, guinea pig, sparrow, and

pigeon as hosts, but he noted that the species is an "irregular feeder" and that "only two or three of each lot of *A. atropalpus* fed at any time on mammals or birds." Laird (1941) recorded that "it was difficult to induce *A. atropalpus* to feed on ducks." We have used man, white rat, and chicken; and, as we have noted previously (Trembley 1945), interrupted feedings are practicable in disease-transmission experiments.

Mating has been observed. Undoubtedly, it customarily takes place in total darkness; because despite almost constant observation, we have never seen mating in full daylight or under electric lights. The constant temperature room, where most of the special experiments are carried out, is in darkness from about 5 P.M. until 8:30 A.M. when the light is turned on for the day. Electric lights of various colors and intensities were used in an attempt to stimulate mating, and also to furnish sufficient light for observation; but the only mating seen thus far was in a cage one evening at twilight. In some instances, a male approached the female as she rested on the side of the container; in others, a male grasped a female as she flew about the cage. In either case, there was a sudden flight of perhaps 3 or 4 seconds as the sexes apparently copulated.

Cross-fertilization attempts were made with *Aëdes atropalpus* and *A. aegypti*. Twenty female *A. atropalpus* pupae were allowed to emerge in a cage with 20 male *A. aegypti;* they were fed as usual. Eleven days after the adults had emerged, 20 eggs were found. These eggs had not hatched in 30 days and were discarded. Concurrently, 20 female *A. aegypti* pupae were placed in another cage with 20 male *A. atropalpus*, and kept under the same conditions as those above. No oviposition occurred. After 30 days, the remaining females and males of each species were transferred so that the sexes of each species were united. Viable eggs were deposited within 2 days. Subsequently, this experiment was repeated, and the results were similar.

Oviposition has not been observed. Attempts to watch females in the act of depositing eggs have failed, although subdued lights of various colors have been used. When lights are turned on, the female which apparently has been ovipositing will remain motionless on the water-surface and eventually fly away; oviposition is resumed during the ensuing period of darkness. Twenty lantern globes each containing a male and a female mosquito, were kept in almost continual total darkness for 6 days. It was not until the electric light was kept on during the day that oviposition occurred. Several months later, a pair of mosquitoes was placed in a lantern globe and set under a cardboard box for 6 days. No eggs were laid. On the third day after removal to light during the day, oviposition occurred, and some of the eggs hatched. One pair of mosquitoes was kept in darkness during the day and under an electric light at night; viable eggs were deposited.

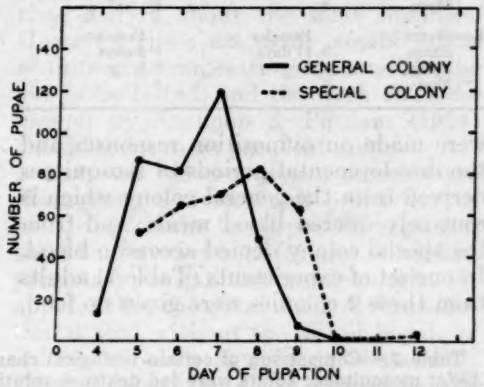

FIG. 2.—Comparison of pupation in the general and in the special colony.

The eggs are laid singly, often in patterns, on open water or on damp filter papers. Occasionally, eggs are deposited in masses like those laid by *Aëdes aegypti;* but in *A. atropalpus* this is apparently due to the inability of a weak or dying female to walk as she oviposits.

Life-cycle of the special colony.—Twenty-five generations of the special colony were completed within 13 months. The period of time elapsing from the immersion of the eggs until pupae began to appear ranged from 4 to 12 days, with a mean of 7.9 and a mode of 7 days. The period of time elapsing from the immersion of the eggs until the appearance of eggs for the next generation varied from 12 to 22 days, with a mean of 15.1 and a mode of 14 days. There were no evident external morphological differences in adults after 24 generations.

Comparison of biological characteristics of the two colonies.—Detailed observations

Table 1.—Comparison of certain biological characteristics of mosquitoes in the general and special colonies. The adults were not fed.

	General	Special
PREOVIPOSITION		
Range	2–5 days (17 ♀ ♀)	2–5 days (10 ♀ ♀)
Mean	3.5	3.2
Mode	3	3
OVIPOSITION		
♀'s ovipositing	17/22 (64.5%)	10/20 (50.0%)
No. eggs laid	1379 81/♀	898 90/♀
Eggs hatched	965 (69.8%)	244 (27.2%)
EGG STAGE		
Hatching starts		
Range	<2–3 days (19 lots)	<2–3 days (8 lots)
Mean	2.5	2.5
Mode	2	2
LONGEVITY	Females	Females
Range	3–11 days	1–6 days
Mean	5.0	3.8
Mode	4	5

were made on oviposition responses and the developmental periods of mosquitoes derived from the general colony which is routinely offered blood meals, and from the special colony denied access to blood. In one set of experiments (Table 1) adults from these 2 colonies were given no food, although distilled water was available. In another set of experiments (Table 2) adults taken from the 2 colonies were fed dextrose solutions. Comparison of these data revealed that unfed mosquitoes are less hardy than fed mosquitoes, but otherwise their reactions are essentially alike.

Preoviposition periods varied, but the lots deposited early in the life of the female were most likely to yield a greater per cent of hatch. After immersion, the egg-stage lasted from less than 24 hours to 24 days. The lots of eggs began to hatch in from less than 1 day to 15 days, and once begun sometimes continued for as long as 4 days. Records were kept (Table 2) on 400 newly-hatched larvae, in 5 lots, derived from each of the 2 colonies. Larvae of the general colony began pupation earlier and pupation reached its peak sooner than in the special colony. (Fig. 2.) Emergence of the adults of both colonies followed similar courses. There was a slight acceleration in the development of the male larvae and pupae in both colo-

Table 2.—Comparison of certain biological characteristics in the general and special colonies of *Aëdes* mosquitoes; adults were fed dextrose solutions.

	General Colony		Special Colony	
PREOVIPOSITION				
Range	2 to 25 days (64 ♀ ♀)		1 to 26 days (49 ♀ ♀)	
Mean	4.8		6.1	
Mode	3		3	
OVIPOSITION				
♀'s ovipositing	64 of 92 (69.1%)		49 of 62 (79.0%)	
Eggs laid	6146 96 per ♀		4908 100 per ♀	
Eggs hatched	3886 (63.2%)		2396 (48.8%)	
EGG STAGE				
Hatching starts				
Range	<1 to 9 days (79 lots)		<1 to 15 days (69 lots)	
Mean	2.5		3.1	
Mode	2		2	
LARVAL STAGE				
No. pupating	358 of 400 (89.5%) 5 lots		344 of 400 (86.0%) 5 lots	
Duration of stage				
Range	4 to 9 days		5 to 12 days	
Mean	6.3		7.1	
Mode	7		8	
PUPAL STAGE				
No. emerging	350 of 400 (87.5%)		336 of 400 (84.0%)	
Duration of stage				
Range	24 to 53 hours		24 to 53 hours	
Mean	45.1		44.3	
Mode	48		48	
LONGEVITY	Males	Females	Males	Females
Range	2 to 36 days	6 to 76 days	6 to 59 days	2 to 81 days
Mean	15.7	36.8	23.7	31.1
Mode	12	44 and 50	25	35

nies. Larval mortality in the general colony was 10.5 per cent, in the special group, 14.0 per cent. Pupae showed a mortality of 2.2 per cent in the general colony and 2.4 per cent in the special colony. The proportion of the 400 larvae from the general colony developing to the adult stage was 87.5 per cent, and of the special colony, 84.0 per cent.

Responses of blood-engorged females.—Only a few females deposit viable eggs after blood meals. Fifteen females from the general colony were allowed to engorge. Nine of these oviposited and only 5 lots contained viable eggs. Of 268 eggs laid, 51 hatched. In another series of 28 females, 12 were induced to bite; and 5 of these mosquitoes, which had previously oviposited without blood, laid 308 eggs. Four of these lots contained a total of 77 viable eggs. The time elapsing between the blood meals and oviposition for 27 females in both series ranged from 4 to 14 days with a mode of 4 and 7 days.

A series of tests has been initiated in order to determine the autogenous characteristics of mosquitoes developing from eggs deposited after blood meals. Eggs from the experiments decribed in the above paragraph were allowed to hatch and the larvae to pupate; 12 of the resulting females, each with a male, were isolated for oviposition without blood. Six of these deposited eggs.

DISCUSSION AND CONCLUSIONS.—A review of the biological characterietics of mosquitoes derived from the general colony, which is offered blood at intervals, and of those from the special colony, denied access to blood, leads to the conclusion that their reactions are similar. The percentage of viable eggs laid is smaller and there is a slight lag in the developmental periods of the special colony, but due to the comparatively small number of experiments performed, the evidence is not conclusive. With the obvious exception of earlier mortality, the life processes of unfed mosquitoes from either colony were like those fed dextrose solutions.

Under the conditions of these tests, more than 50 per cent of the females from each colony oviposit without blood meals, and about half of the eggs deposited hatch. It is probable that this percentage of females ovipositing, and the resulting number of viable eggs, may be altered by changing the constituents of the nourishment furnished in the larval stage.

It may be presumed, also, that an alternation of light and darkness is necessary for the deposition of viable eggs. Further investigations on oviposition might well be undertaken with the aid of infra-red light and film and a moving-picture camera with a shutter actuated by a timing mechanism.

Eggs conditioned by slow-drying for 2 days at temperatures of approximately 28° to 30° C., and those immersed immediately yield larvae at about the same time and in about the same numbers. However, there are many combinations of time and temperature for conditioning yet to be tested; and the work on *Aëdes aegypti* by Shannon & Putnam (1934) should serve as an excellent guide.

Data on blood-engorged females are incomplete. Only a small proportion of blood-fed females has deposited eggs; and these have always been females which had previoulsy oviposited autogenously. It appears that the usual mode of reproduction is that without the aid of blood, or indeed without any food whatsoever. Further experiments are planned to test these points and data will be compiled on the number of larvae hatching from eggs laid by females previously engorged on blood, with the resulting effects on the life-processes and eventually the biting propensities of the females. An attempt will be made to determine whether selective breeding will develop females with a greater tendency to bite.

The rearing of this species in numbers offers interesting possibilities. *Aëdes atropalpus* is distributed throughout most of the United States, with the exception of the Far West; and it may safely be used in many localities where the easily-reared *A. aegypti* is not found in nature. In laboratories where larvae are used for insecticide and physiological studies, it may be advantageous to rear large numbers of this species without the necessity of maintaining animals to provide blood meals for the adult mosquitoes.

SUMMARY.—*Aëdes atropalpus* is autogenous (may breed without feeding in the adult stage), stenogamous (may mate in comparatively small spaces), homodynamic (has no diapause, or seasonal period of comparative inactivity) and does not exhibit spanogamy (a decrease in the number of females with the increase in

successive generations). A colony in which the females have been denied blood has been reared in the laboratory for more than a year. The colony is now in its twenty-sixth generation and shows no loss of vigor. The life-cycles of individuals from the general and from the special colonies do not differ greatly. The average time elapsing from emergence of the adults until the appearance of adults of the next generation is approximately 15 days for those derived from the general colony, and 18 days for those from the special colony. The females of this species may be induced to bite when blood meals are offered, and subsequent oviposition results in comparatively few viable eggs.[1]

—11-21-46.

[1] Acknowledgements.—Appreciation is expressed to Dr. Newell E. Good, formerly of Malaria Control in War Areas, U. S. Public Health Service, who furnished specimens for the establishment of the original colony; and to Dr. Alan Stone, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, who examined reared material throughout the course of these experiments. Acknowledgement is made of the valuable technical aid rendered by the following laboratory assistants: Roslyn Handler, Mera Riddell, and Louise Goode.

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Southern Corn Rootworm as a Pest of Peanuts[1]

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The southern corn rootworm, *Diabrotica duodecimpunctata* (F.), is a potentially serious insect pest of growing peanuts. Injury is principally caused by the larvae boring into the pods and feeding on the kernels and on the more succulent tissue of the surrounding pod. Even where the amount of feeding done by the larvae may not be serious, the pods are predisposed to decay from soil microorganisms. The pods are highly susceptible to injury from the time they begin to form until they approach maturity and become tougher. Often the tips of the shoots or "pegs" will be attacked and killed before they begin enlarging to form pods. Even the more mature pods are not immune to injury, although they are not as readily attacked as younger pods. Pods which appear normal upon superficial examination will often, upon closer examination, show severe injury and decomposition on the inside. It is not unlikely that many of the so-called "pops" among peanuts are caused in this way.

Injury to peanut pods from the southern corn rootworm has been reported by Fink (1916) who described the injury and published two photographs of injured pods. Miller (1943), working in eastern Virginia, reported this insect to be the most important pest of peanut pods in the soil.

The main purpose of this paper is to present the results of a 3-year study (1944-46) of the southern corn rootworm as a pest of peanuts in Virginia. Most of the observations were made at the Tidewater Field Station of the Virginia Agricultural Experiment Station, located at Holland, because most of the peanuts produced in Virginia are grown in about nine counties located in the southeastern section.

Economic Importance.—Surveys to determine the extent of injury to peanut pods from the southern corn rootworm were made at harvest time during three consecutive years. Peanut fields located in three or four counties were included in the survey for each year. In 1944 and 1945 the percentage of injured pods for each field was estimated in the field, but in 1946 a sample of peanuts was taken from each field and later examined in the laboratory to determine the exact percentage of injured pods. The plants composing each sample were taken at random from different locations in the field. Pods less than 0.75 inch in length were not considered, and superficial injury which failed to penetrate the endocarp of the pod was disregarded.

The amount of injury to peanut pods from the southern corn rootworm increased rapidly during the 3-year period of observation reported herein. In 1944 the injury was found to be generally light in the 50 fields examined. In 1945 the percentage of injured pods varied from almost none to 38 per cent, with an average of approximately 12 per cent for the 44 fields examined. In 1946 injury to peanut pods from the southern corn rootworm was very severe in many fields. From 64 fields examined, an average of 28.1 per cent of injured pods was obtained. The percentages of injured pods were distributed as follows: over 50 per cent injured pods in 10 fields; from 25 to 50 per cent in 14 fields; from 10 to 25 per cent in 29 fields; and under 10 per cent injured pods in 11 fields.

Factors Affecting Injury.—While making the surveys previously described, attempts were made to evaluate certain indirect factors which might influence the population level of the southern corn rootworm and the extent of injury it causes to peanut pods in the soil. Accordingly, observations were made in each field on the soil type, the physical condition of the soil, the extent of vine growth, and the proximity of growing corn.

The most important indirect factor affecting injury to peanut pods from the southern corn rootworm appeared to be the physical condition of the soil as influenced by the amount and timing of rainfall throughout the growing season. Injury was generally more severe in moderately stiff soils that had a tendency to

[1] Eastern Branch Program.

[2] Acknowledgment is made to E. T. Batten, Superintendent of the Tidewater Field Station, Va. Agr. Expt. Sta., for assistance in various ways throughout the course of this study; and to Boyd Harshbarger, Statistician, Va. Agr. Expt. Sta., for the statistical analyses of the data.

remain moist than in well-drained, light soils. However, injury was by no means restricted to soils of the former characteristics.

No positive correlation was observed between soil type and amount of organic matter and injury, except indirectly through the coincidence of drainage being an important factor in producing different soil types. The proximity of corn appeared to have little, if any, effect upon the amount of injury. Usually more injury was observed in fields with good to excellent foliage growth than in those of poor vine growth.

LIFE HISTORY.—General observations were made on the life history of the southern corn rootworm through successive generations in a screened insectary. The rearing was done in 12 by 12 by 12-inch screened cages with a tray of soil under each. Early in the spring hairy vetch was rooted in each tray to serve as food, but later the adults were fed on the blossoms of various flowers and corn was sprouted in the soil to furnish food for the larvae. The approximate date when eggs were first deposited in the spring was determined by caging field-collected adults for successive periods and later examining the soil underneath the cages for the presence of larvae.

In 1945 eggs were deposited in the soil of the cages by the overwintering adults of the southern corn rootworm during the period March 16 to 24, but it is not known whether or not oviposition occurred earlier, since no adults were caged before this period. In view of the unseasonably warm weather during most of March, however, it is likely that eggs were deposited in the field prior to March 16. In 1946 eggs were deposited in the cages as early as March 13 to 21; during this period maximum air temperatures considerably in excess of 70° F. occurred on three consecutive days (Fig. 1). No eggs were obtained from overwintering adults caged prior to this period.

Three generations of the southern corn rootworm were reared in the screened insectary during the 1945 season. The first-brood adults (from eggs deposited early) emerged from May 31 to June 13; the second-brood adults emerged from July 24 to 31; and the third-brood adults emerged during the period September 10 to 26. Although the third-brood adults were caged and fed as previously described, no eggs were deposited by them. In the 1946 season difficulty was experienced in rearing the southern corn

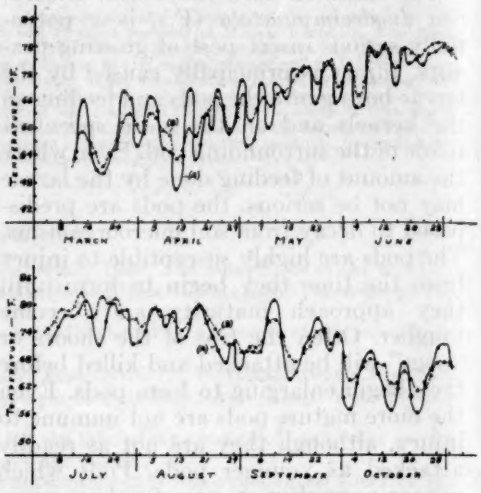

FIG. 1.—Mean air (A) and soil (B) temperatures for 1946 at Holland, Virginia. Air temperatures taken in a screened insectary, and soil temperatures taken at a depth of 6 inches under peanut plants grown nearby.

rootworm through successive generations but it is likely that it completed three generations. The first-brood adults (from eggs deposited March 13 to April 5) emerged from June 3 to 22. For some unexplained reason no second-brood adults emerged in the screened insectary. However, field observations of adults on peanut foliage and larvae and pupae in the soil under peanut plants, made throughout the season, indicate that the second-brood adults emerged about the last week in July, and third-brood adults emerged during late September and early October.

Mean air and soil temperatures for the 1946 season, as determined from thermographic records, are presented in figure 1 to make more understandable the life history observations reported herein. Similar temperature records for a portion of both the 1944 and the 1945 seasons have been previously published (Grayson 1945).

LABORATORY CONTROL.—Information was obtained in the laboratory on the toxicity of DDT and benzene hexachloride to the southern corn rootworm by caging the adults over soil treated with

different rates of these materials. From 24 to 30 adults were confined in each cage for a period of at least two weeks, or longer if cool weather prevailed. The adults for each cage of a series were taken at random in groups of 2 or 3 from a stock cage; it was not considered feasible to divide the sexes equally between the cages of each series, because they are rather difficult to distinguish (Smith & Allen 1931), and the insects might become injured in handling. Fresh food, consisting of the blossoms of various plants, was maintained at all times in the cages, and the soil in the trays underneath was kept moist. The numbers of larvae present in the different trays were determined by screening the soil 10 to 14 days after the removal of the adults from the cages.

Approximately 4.5 inches of soil was placed in each tray and the toxicant was thoroughly mixed with the top 1.5 to 2.0 inches of soil. The desired amounts of DDT in most cases were obtained from a stock material containing 10 per cent DDT, while the desired amounts of benzene hexachloride were obtained from a stock material containing 10 per cent of concentrate (all isomers) and approximately 3 per cent of gamma isomer. An untreated check was included with each series. The results are shown in table 1. Except for the survival of one larva, complete control was obtained in all of the treated soil, even at the lowest rates of application (per acre). Also, the soil treated with the higher rates of benzene hexachloride appeared to be toxic to the adults caged over it. However, the results obtained with benzene hexachloride should be considered as only preliminary since, in most cases, they are based on single tests.

Table 1.—Soil treatments in the laboratory for control of the southern corn rootworm. Holland, Virginia. 1946.

Pounds per Acre[1]	Number of Tests	Average Number of *D. duodecimpunctata* Recovered	
		Adults[2]	Larvae[3]
Tests with DDT			
100	2	13.5	0.0
50	3	10.7	0.0
25	3	13.0	0.3
10	4	12.5	0.0
5	2	12.5	0.0
Check (untreated)	4	14.3	70.3
Tests with Benzene Hexachloride			
50	1	0.0	0.0
25	1	0.0	0.0
10	2	4.5	0.0
5	1	12.0	0.0
Check (untreated)	2	9.0	80.0

[1] Amounts of DDT in terms of actual DDT; amounts of benzene hexachloride in terms of concentrate (all isomers) which contained approximately 30 per cent gamma isomer.
[2] Alive at time of removing adults from cages.
[3] Found in soil.

FIELD CONTROL.—Information was obtained in the field on the control of the southern corn rootworm from the application of different rates of DDT to the soil, and from the periodic dusting of the foliage with sulfur and low concentrations of DDT in combination with sulfur. The sulfur and DDT-sulfur dusts were applied in an experiment for the control of leaf spot and potato leafhopper on peanuts, but advantage was taken of the opportunity to make observations on possible control of the southern corn rootworm.

Soil applications of DDT were made at rates of 25, 50, and 100 pounds per acre on each of two different dates, to a dark soil (Bladen type) only moderately well drained. A plot size of 1 square rod was used, and each treatment (with an untreated plot) was replicated four times in a latin square design on each date. The materials were applied by hand and the land was plowed soon afterward with a 5-hoe cultivator. The results were determined by drawing a sample (composed of 3 or 4 plants taken at random) from each plot, removing and washing the pods, and carefully examining them for injury. Only pods greater than 0.6 inch in length were considered, and those showing superficial injury which failed to penetrate the enddocarp of the pods were considered as uninjured. The results (Tables 2 and 3) were tested by the analysis of variance, after first converting percentages to angles. The difference between treated and untreated plots for each date of application was highly significant. On either date of application there was no significant difference between the results obtained from 25 and 50, or 50 and 100, pound per acre rates of DDT; however, when the results of both dates of application were combined, the differences between these treatments were significant. The combined analysis also showed that the treatments applied on June 18 were

Table 2.—Soil applications of DDT made on June 18 for control of the southern corn rootworm attacking peanut pods. Holland, Virginia. 1946.

Pounds per Acre	Number of Replicates	Number of Pods Examined (Average)	Injured Pods (Average)		Per Cent Reduction
			(Per Cent)	(Angles)	
100	4	288.0	4.28	11.68	84.4
50	4	212.3	8.80	16.84	68.0
25	4	334.3	13.90	21.69	49.5
Check (untreated)	4	337.8	27.51	31.56	—

Differences (expressed as angles) required for significance at odds of: 19 to 1 = 5.68
99 to 1 = 8.16

significantly better than those applied on July 11.

In a preliminary test in 1945, DDT was added to the soil on July 30 at rates of 25, 50, and 100 pounds per acre at each of two different locations. The results indicated that considerable control of the southern corn rootworm was obtained from DDT at rates of 50 or 100 pounds per acre, whereas only slight control was obtained from the 25-pound per acre applications. The number of injured pods in the various plots was consistently higher on September 11 than on September 26;

Table 3.—Soil applications of DDT made on July 11 for control of the southern corn rootworm attacking peanut pods. Holland, Virginia. 1946.

Pounds per Acre	Number of Replicates	Number of Pods Examined (Average)	Injured Pods (Average)		Per Cent Reduction
			(Per Cent)	(Angles)	
100	4	292.0	10.44	18.78	74.3
50	4	314.3	15.46	22.10	61.9
25	4	337.8	21.31	27.38	47.5
Check (untreated)	4	299.8	40.55	39.43	—

Difference (expressed as angles) required for significance at odds of: 19 to 1 = 7.46
99 to 1 = 10.75

this would undoubtedly be attributed to the rapid deterioration of injured pods in the soil at this time. The observable injury at time of digging is probably much less than the maximum which occurs earlier.

The dust applications made to peanut foliage in 1946 consisted of four treatments which were each replicated four times. Each plot was 16 rows wide by 100 feet long. The plots were randomized within each block but the blocks were arranged in a linear series. A large area on either end and one in the middle between the second and third blocks were left untreated to serve as checks. The results were determined by drawing a sample from each plot and examining the pods as previously described, and are summarized in table 4. The data obtained from

Table 4.—Control of southern corn rootworm obtained from various dusts applied to peanut foliage. Holland, Virginia. 1946.

Treatment[1]	Number of Replicates	Number of Pods Examined (Average)	Injured Pods (Average)		Per Cent Reduction
			(Per Cent)	(Angles)	
Sulfur[2]	4	186.5	28.80	32.13	17.9
Sulfur+1% DDT	4	207.8	25.69	30.42	26.7
Sulfur+2% DDT	4	219.3	21.85	27.80	37.7
Sulfur+2% DDT[3]	4	176.5	23.60	29.01	32.7
Difference between treated plots not significant.					
Check (untreated)	3	174.7	35.07		

[1] Applications made on July 12, July 29, and August 21.
[2] Sulfur used in all plots was 325-mesh dusting sulfur.
[3] Sulfur alone applied on date of third application.

the treated plots were tested by the analysis of variance. There was no statistically significant difference between treatments. An unreplicated test of a similar nature made in 1945 indicated that 3 applications of DDT-sulfur mixtures or compounds to peanut foliage (DDT up to 5 per cent) would give very little control of the southern corn rootworm.

During 1945, at Beltsville, Maryland, small plots were sprayed June 18 and 23, and July 7 with a suspension of DDT (0.66 per cent) for the control of tobacco thrips. The infestation by the southern corn rootworm was reduced 52 per cent. Five applications of 2 per cent DDT-pyrophyllite dust to similar plots during 1946 reduced the infestation 85 per cent. The maximum number of infested pods observed was 26 per cent (4 per cent severely injured). These fragmentary data indicate that combined programs for control of thrips and potato leafhopper-leafspot would perhaps give greater reduction in number of pods injured by the southern corn rootworm than the latter program alone.

PHYTOTOXICITY.—Preliminary tests were made to determine the tolerance (at time of germination and during the seedling stage of the plants) of corn, cotton, peanuts, and soybeans to soil applications of

DDT and benzene hexachloride. The experiment consisted of four adjacent 6- by 6-foot plots. The treatments were not replicated but the seeds of each plant species were planted in two randomized rows of 30 seeds each within each plot. One plot was treated with DDT at the rate of 200 pounds per acre (actual DDT) and two plots were treated with benzene hexachloride at the rate of 100 pounds per acre of concentrate (30 pounds per acre of gamma isomer). The fourth plot was left untreated. The materials were applied by hand and mixed with the top 1.5 to 2.0 inches of soil by means of a hoe. The soil was fine sandy loam (Norfolk type) with a low percentage of organic matter.

On the plot treated with DDT no noticeable differences were observed in germination and later growth of the plant species under test as compared with germination and subsequent growth on the untreated plot. In one plot treated with benzene hexachloride (seed planted day following application of insecticide to soil) almost complete kill of corn resulted soon after germination; 85 per cent of the peanuts germinated, but only 20 per cent lived; 90 per cent of the cotton germinated, and 54 per cent lived; 88 per cent of the soybeans germinated, and 56 per cent lived. In another plot treated with benzene hexachloride (seed planted 10 to 12 days following application of insecticide to soil) almost complete kill of corn resulted soon after germination; 88 per cent of the peanuts germinated, but only 27 per cent lived; 79 per cent of the cotton germinated, and 56 per cent lived; good germination of soybeans resulted but only 34 per cent lived.

DISCUSSION.—In view of the rather mild climate and the length of the growing season which usually occurs in southeastern Virginia (Fig. 1), the probable occurrence of 3 generations each year of the southern corn rootworm would appear to be in accord with the seasonal development of this insect as reported from other sections of the United States. Three complete generations and a partial fourth have been reported for Alabama (Arant 1929); as many as 3 generations may occur in Arkansas (Isely 1929). But only one generation has been reported to occur annually in Iowa (Sweetman 1926).

Several factors may have contributed to the extent of injury to peanut pods by the southern corn rootworm during the 1946 season. The moisture content of the soil is perhaps the most important single factor in regulating the population level of this insect. Since the amount and timing of rainfall during the consecutive seasons of 1945 and 1946 were such as to prevent the soil from drying out thoroughly at any time, except in a few small areas, this insect was able to attain a high population level and to continue to develop at this level. In low, wet areas injury can usually be found even in seasons of rainfall scarcity but during the past two seasons it was distributed generally over most fields. However, other factors such as soil type, amount of organic matter, and extent of vine growth probably exert an indirect influence through helping to conserve the moisture content of the soil; and it is likely that prolific vine growth attracts the adults.

From data obtained in laboratory tests in which DDT and benzene hexachloride were applied to the soil it appears that either of these materials at rates as low as 5 pounds per acre is highly toxic to the southern corn rootworm. The failure of field applications of DDT at rates of 25, and even 50, pounds per acre to give better control than was obtained in these studies can probably be attributed largely to the DDT not having been thoroughly mixed with the soil. Other factors, such as leaching and direct sunlight, may have caused some of the DDT to be lost or to have deteriorated in insecticidal effectiveness. Further studies giving special attention to methods of application and to thoroughness of mixing the toxic material with the soil are needed.

SUMMARY.—Results are presented of a 3-year study of the economic importance, life history, and control of the southern corn rootworm as a pest of peanuts in southeastern Virginia. Field surveys at harvest time each year indicated light damage in 1944, about 12 per cent of the pods injured in 1945, and serious damage to developing pods during 1946 when an average of 28.1 per cent of injured pods was determined from an examination of 64 peanut fields located in three counties.

In 1945 and 1946 eggs were deposited in a screened insectary by the overwintering adults of the southern corn rootworm as early as the third week in March. Laboratory and field observations made the

same years indicated three generations annually.

Complete control of the southern corn rootworm was obtained in the laboratory with soil applications of actual DDT or benzene hexachloride concentrate (30 per cent gamma isomer) at rates as low as 5 pounds per acre. In the field, soil applications of DDT at 25, 50 and 100 pounds per acre gave corresponding reductions of 47 to 84 per cent in numbers of pods injured.

In a small trial in outdoor plots a soil application of 200 pounds of DDT per acre caused no noticeable difference in germination and early growth of peanuts, corn, cotton, and soybeans as compared with that on an untreated plot, but a soil application of 100 pounds of benzene hexachloride (30 pounds of gamma isomer) per acre greatly reduced germination and early growth of all of these crops.—2-18-47.

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An Analysis of the DDT Spray Program for Controlling Codling Moth[1,2]

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In the course of our work with fruit growers in western New York, particularly during periods of low prices, we are frequently questioned in considerable detail with regard to abbreviated spray schedules, how such departures from the standard recommendations may affect the control of the codling moth, and which of the scheduled applications may be omitted with the least likelihood of serious losses. For example—what control may be expected from three of the five or more recommended cover sprays? How much residue would be left on mature fruit after such a schedule? What degree of control is possible from two cover sprays? When following a five-spray program using DDT what precautions should be taken to avoid a residue problem? These and similar questions are difficult to answer intelligently without actual experience.

For a number of years we have followed the practice of carrying through each season a series of plots treated with the individual cover sprays and various combinations of cover sprays to furnish data on both insect control and spray deposit. The program requires the use of approximately 20 mature trees each bearing at least 10 bushels of fruit. Fifteen trees receive the spray treatments and the remainder are left unsprayed as checks. The check trees are located at intervals between the sprayed trees and are very important as they aid in furnishing a steady supply of insects all through the season.

Up to this year lead arsenate has been employed as the insecticide in the tests. This past season DDT was substituted for the arsenical.

The plot diagram for the treatments is given in figure 1. It would be highly improbable that the plots would be laid out exactly as in the diagram. More often the trees selected will be in one or two rows.

[1] Journal Paper No. 693, New York State Agricultural Experiment Station, Geneva, N. Y. Nov. 21, 1946.
[2] Eastern Branch Program.

Table 1.—Codling moth control with DDT; also spray deposit on mature fruit at harvest from different combinations of cover sprays. Two pounds of a 50 per cent DDT wettable powder were used in 100 gallons.

TREE NUMBER	COVER SPRAYS	WORMS IN 100 APPLES	RESIDUE GRAINS PER LB.[1]
	checks, no sprays, average	51.4	
1	1	27.1	<.001
2	1, 2	22.3	<.001
3	1, 2, 3	7.2	<.001
4	1, 2, 3, 4	1.3	.010
5	1, 2, 3, 4, 5	0.3	.021
6	2	15.3	<.001
7	2, 3	7.5	.007
8	2, 3, 4	4.4	.001
9	2, 3, 4, 5	1.8	.030
10	3	11.0	<.001
11	3, 4	9.1	.004
12	3, 4, 5	9.0	.007
13	4	14.6	.001
14	4, 5	16.7	.016
15	5	19.9	.007

[1] Samples for residue analyses were taken after the fruit had been picked in canvas bags and run over the sorting table.

Table 2.—Codling moth control with DDT; also spray deposit on mature fruit at harvest from different combinations of cover sprays. One pound of technical DDT dissolved in 1 quart of benzene and emulsified with 2 to 3 ounces of *Triton B-1956* was used in 100 gallons of spray.

TREE NUMBER	COVER SPRAYS	WORMS IN 100 APPLES	RESIDUE GRAINS PER LB.[1]
	checks, no sprays, average	27.0	
1	1	15.9	<.001
2	1, 2	4.7	<.001
3	1, 2, 3	1.0	.008
4	1, 2, 3, 4	0.7	.022
5	1, 2, 3, 4, 5	0.7	.045
6	2	6.7	<.001
7	2, 3	5.1	.003
8	2, 3, 4	1.5	.034
9	2, 3, 4, 5	2.4	.034
10	3	9.5	<.001
11	3, 4	6.8	.010
12	3, 4, 5	9.7	.032
13	4	13.6	.002
14	4, 5	14.0	.030
15	5	16.3	.007

[1] Samples for residue analyses were picked direct from the trees into paper bags to avoid removal of spray residue.

For convenience and to avoid confusion when applying the sprays, the trees are numbered from 1 to 15 corresponding to the diagram. A nail is driven in each tree on which to hang a tin can or other conspicuous marker. When a treatment is to be made the markers are hung on the trees to be sprayed. After the application, the marker is removed and in this way errors in making treatments are avoided. In the case of shy bearers, more than one tree may be used.

The full schedule consisted of five cover sprays using one pound of actual DDT in 100 gallons. Three applications were made to combat the first brood worms. These were applied on June 17, July 1 and July 12. The two sprays for second brood were made on August 6 and 21. Tests this past season included two series of 15 trees each, the plots being located in different parts of the same orchard. All trees were of the McIntosh variety. The data on control and residues are given in tables 1 and 2.

The figures on control indicate that for this season the third and second cover sprays were those most effective in preventing codling moth injury. The fourth cover spray was next in order and the fifth and first sprays afforded least protection. There being a considerable variation in the infestation in different parts of the orchard, as shown by the check trees, it would appear that the control data given in the tables suggest only trends and a difference of a few figures one way or the other should not be considered as significant. Injury on check trees shown in table 1 ranged from 37 to 74 worms per 100 apples. Those in table 2 from 17 to 37 per cent. As the amount of injury on the check trees appearing in table 1 is considerably greater than that in table 2, it would seem that the figures on control as expressed in table 1 would be more representative of the actual value of the different treatments. However, in general, the relative values of the corresponding sprays in the tables are in agreement.

It is interesting to compare control with lead arsenate to that with DDT in a five-spray program, the applications being made at approximately 2-week intervals. Three pounds of lead arsenate in 100 gallons allowed 16 per cent worms with the usual number of accompanying stings as compared to less than 1 per cent worms and no stings from a DDT program using 1 pound of actual DDT in 100 gallons.

Dr. A. W. Avens of this Station made the residue determinations using the pyridine-xanthydrol-potassium hydroxide method as described by H. V. Claborn.[1]

[1] H. V. Claborn, Determination of DDT in the presence of DDD, Association of Official Agricultural Chemists, 29 (3), 330–337, 1946.

This is essentially a color test method using the *Lumetron* colorimeter.

Spray residue data appearing in table 1 represent the amounts remaining after the customary handling during the harvesting operation. These residues are all well below .05 grain per pound, the present tentative tolerance for DDT. On similarly sprayed fruit using the same 50 per cent wettable DDT powder, samples taken directly from the trees and placed in paper bags to avoid removal of DDT residue showed amounts 2 to 3 times that shown in the table. For example, trees receiving the full schedule of five sprays retained .064, .043, .045, .044 and .052 grain per pound. These data suggest that residue removal incident to a harvesting operation may be considerable. An examination of the various treatments reveals that without exception the last applications in the spray schedules were responsible for the heaviest deposits on the fruit at harvest.

The residue figures given in table 2 represent the deposit from a DDT-benzene spray (1 pound technical DDT dissolved in 1 quart benzene for each 100 gallons). The samples for determination were carefully removed from the trees to avoid disturbing the deposit.

The final application in the five cover spray program was made on August 21 and the fruit was harvested on September 16. This allowed an interval of 26 days of weathering, a very important point in relation to harvest residues. It would appear that an interval of about one month between the final spray and harvest is desirable following a five-spray DDT program to comply with the present tolerance requirements.

CONCLUSIONS.—From the results of a series of treatments used to break down the full spray schedule used for combatting the codling moth, it was indicated that the efficiency of individual cover sprays arranged in order of importance placed the third and second cover sprays as those most effective, the fourth cover next in order, and finally the fifth and first sprays as those of least importance. As the season of 1946 was not an average season, it is probable that this arrangement of sprays according to their importance may vary somewhat under more normal conditions.

A full schedule of five DDT sprays using one pound actual DDT in 100 gallons, and allowing an inverval of approximately a month between the final spray and harvest, met tolerance requirements. The late season applications were those most important in building residues. Handling incident to harvesting removed considerable residue.—11-21-46.

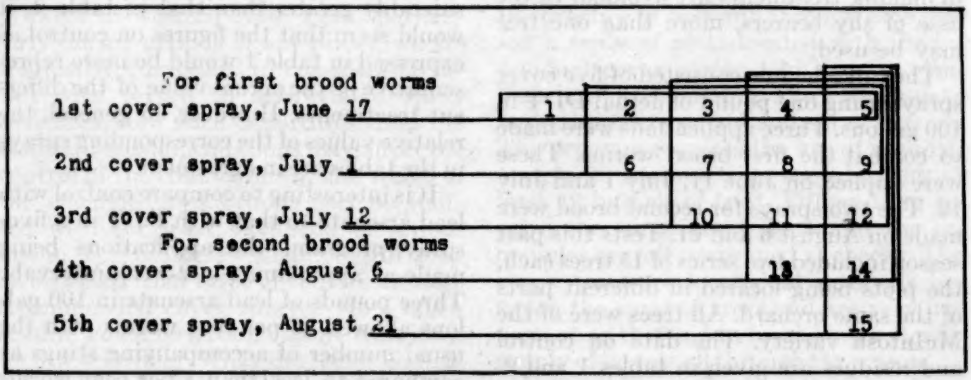

FIG. 1.—Diagram showing the timing of the various treatments. Trees number from 1 to 15.

1st cover spray applied to trees	1, 2, 3, 4, 5
2nd cover spray applied to trees	2, 3, 4, 5, 6, 7, 8, 9
3rd cover spray applied to trees	3, 4, 5, 7, 8, 9, 10, 11, 12
4th cover spray applied to trees	4, 5, 8, 9, 11, 12, 13, 14
5th cover spray applied to trees	5, 9, 12, 14, 15

The number of sprays received by individual trees corresponds to the number of times that tree number occurs in the above listing. The time of application corresponds to the date given for the cover spray in the diagram.

Testing Tick Repellents and Observations of Phototropic Effects[1, 2]

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During the course of laboratory evaluation of chemicals for repellency to ticks it was noted that the responses of the ticks were affected by varying intensities of light. Although to date our observations of this phototropic response are largely of a preliminary and exploratory nature, the reactions of the ticks are so marked that it seems worth while to present a brief report at this time.

METHODS.—At present we are using the lone star tick, *Amblyomma americanum*,[3] for our studies. In our early work with repellents we sprayed an 11 cm. filter paper in such a way that the center portion, a 6 cm. diameter circle, was free of spray material. Five tick nymphs were placed in the untreated center and the number of crossings into the surrounding treated area was observed for 5 minutes.

The relative effectiveness of a series of treatments could be ascertained by comparing the number of crossings into the treated area with the crossings into some recognized standard tested during the same day. Unfortunately, it was found that the number of crossings made into replicate treated areas during a test period might vary by a considerable margin depending on a number of conditions which affect activity of the ticks. We have consequently modified our procedure so that a direct comparison can be made between two chemicals or between a test treatment and an untreated area. This is accomplished by covering half the test paper with a glass plate while spraying with the test chemical. The center portion is protected from the spray by a 6 cm. diameter tin disc. See fig. 1. After treatment, by placing ticks in the central untreated area the number of crossings into either the treated or the untreated surrounding semicircle can be observed. if a direct comparison with another chemical is desired it can be obtained by covering first one side and then the other thus producing two semicircles of treated areas surrounding an inner circle of untreated area.

A 1 per cent sodium oleate solution in water is used to disperse 5 per cent concentration of chemicals under test. Five cubic centimeters of liquid is used per treatment, applied with a *G. S. Devilbis* type sprayer. Of this 5 cc. only approximately 3 cc. actually hits the test surface. The treated paper is allowed to stand for 10 minutes to permit evaporation of the liquid to partial dryness, as a wet surface tends to inhibit the test tick's movement into the treated area.

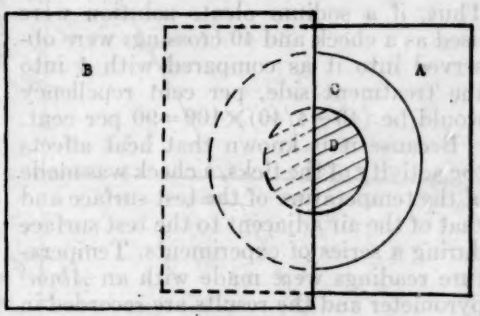

FIG. 1.—Filter paper test surface prepared for treatment. A.—Lower glass plate; B.—Upper glass plate; C.—Filter paper; D.—Tin disc.

When it was suspected that the ticks, especially the nymphs, were attracted to the side of greatest light intensity, it was decided to make some experimental observations to determine the degree of this attractiveness. Two *Mazda* lamps were adjusted so that at first each half of a test paper received equal illumination. Then the intensity of one of the lights was gradually reduced. Differences in illumination ranged from 0 foot candles (as measured by a *Weston Illumination Meter, Model 603*), when the lights were evenly adjusted (actual illumination 40 f.c.), to 35 foot candles. The results have been illustrated in the accompanying figures 2 to 9 expressed as per cent attractiveness or repellency in relation to foot candle

[1] Journal Series Paper. New Jersey Agricultural Experiment Station, Rutgers University, Department of Entomology. Research Fellowship sponsored by Carbide and Carbon Chemicals Corporation.

[2] Eastern Branch Program.

[3] The ticks used were from a culture, the original stock of which had been supplied by Carroll N. Smith of the U.S.D.A., Bureau of Entomology and Plant Quarantine.

illumination differences. Each point on the curves represents the average of 3 to 5 tests.

Per cent attractiveness has been determined by the following formula:

$$\text{Per cent attractiveness} = \frac{\text{Crossings to one side} - \text{Crossings to other side}}{\text{Total number of Crossings}} \times 100.$$

Thus, if 30 crossings were observed to the right side of the test paper and 10 to the left, per cent attractiveness to the right would be $(30-10/40)\times 100=50$ per cent.

Per cent repellency has been determined by the following formula:

$$\text{Per cent repellency} = \frac{\text{Check Crossings} - \text{Treatment Crossings}}{\text{Check Crossings}} \times 100.$$

Thus, if a sodium oleate solution were used as a check and 40 crossings were observed into it as compared with 4 into the treatment side, per cent repellency would be $(40-4/40)\times 100=90$ per cent.

Because it is known that heat affects the activity of the ticks, a check was made of the temperature of the test surface and that of the air adjacent to the test surface during a series of experiments. Temperature readings were made with an *Alnor*[1] pyrometer and the results are recorded in table 1. It was found that at the beginning of a test series, when the light was uniform, *i.e.*, 40 foot candles on each half of the test surface the temperature on both halves of the test surface was 80° and that of the air 78° F. As the test continued and the light was reduced on one half and kept constant on the other half, the temperature rose slightly to 82° at the test surface and 81° F. in the air but even at the widest difference in illumination, 35 foot candle difference, there was only 1° F. difference in temperature between the halves of the treated surface. It is not believed likely that this small difference influenced the phototropic effect. A further check using fluorescent lights from which no temperature differences were discernible tends to bear out this conclusion.

Table 1.—Temperature at treated surface and adjacent air under varied light conditions.

Light Intensity		Test Surface		Air	
Foot Candles		° F.		° F.	
Left Half	Right Half	Left	Right	Left	Right
40	40	80	80	78	78
40	30	81	81	79	79
40	20	82	82	80	79
40	10	82.5	82	80	79.5
40	5	82	81	81.5	81

[1] Illinois Testing Laboratory.

OBSERVATIONS ON NYMPHAL STAGE.—Figure 2 illustrates the effect when both halves of an untreated surface were com-

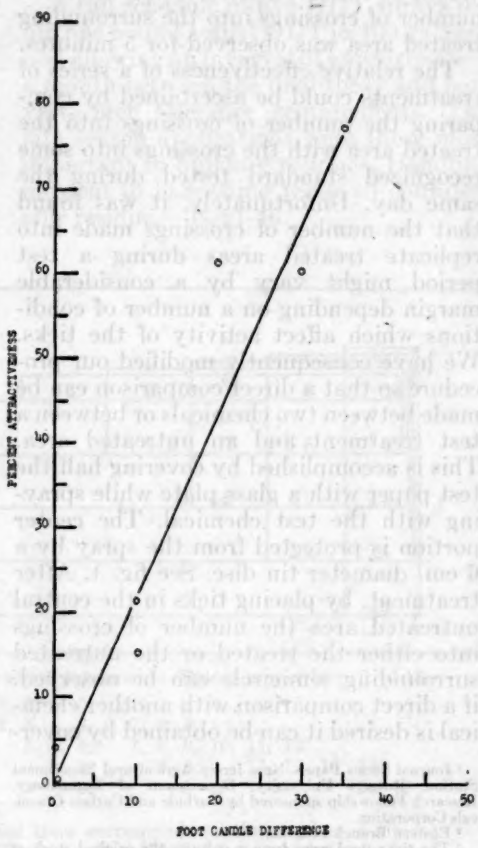

FIG. 2.—Attractiveness of light to tick nymphs when both halves of test surface are untreated.

pared. When illumination was equal, the tick nymphs crossed to each side uniformly. When there was a 10 foot-candle difference, the ticks exhibited approximately a 20 per cent attractiveness towards the side of greater light intensity. At a 20 foot-candle difference, there was approximately 60 per cent greater attractiveness toward the side of greater light intensity. This rose to 80 per cent at a 35 foot-candle difference.

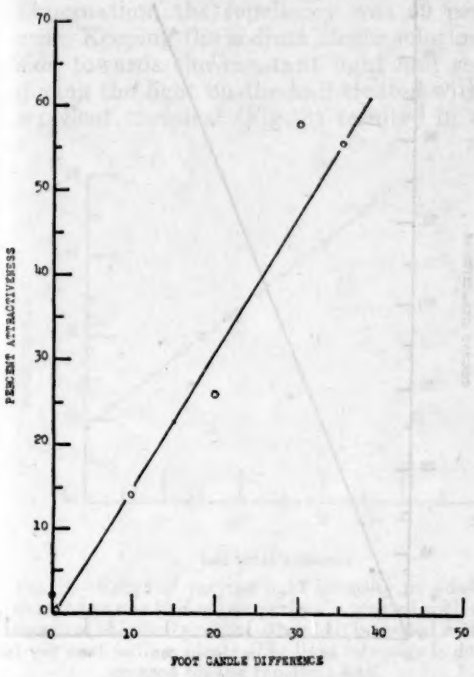

FIG. 3.—Attractiveness of light to tick nymphs when both halves are treated with 1 per cent sodium oleate.

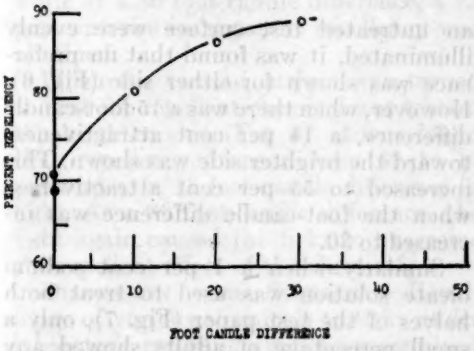

FIG. 4.—Effect of varying light intensity on tick nymphs when one half of test surface is treated with a repellent chemical and the other half is treated with 1 per cent sodium oleate. The light intensity is decreased on the repellent half.

When both halves of the paper were treated with 1 per cent sodium oleate solution, the tick nymphs were again attracted toward the side having the greatest light intensity (Fig. 3) although the actual attractiveness was not so strong as when the paper was dry. At a 20 foot-candle difference the per cent attractiveness toward the brighter side was approximately 25, and at a 35 foot-candle difference there was 55 per cent attractiveness.

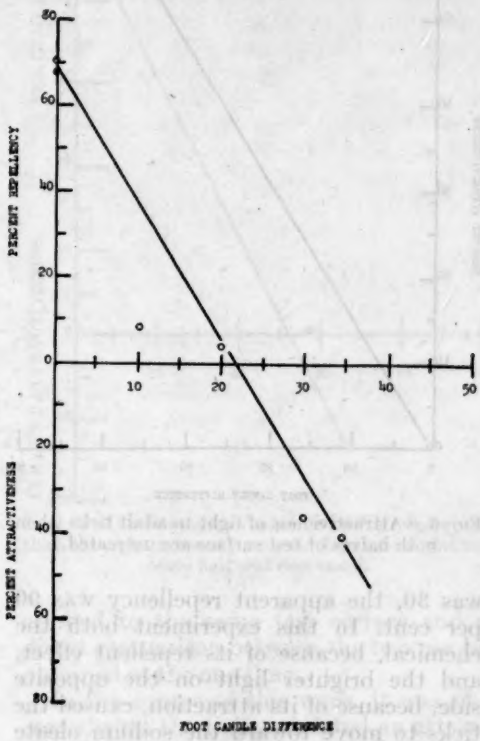

FIG. 5.—Conditions the same as in Fig. 4, except that the light intensity on the 1 per cent sodium oleate half was decreased.

Figure 4 illustrates the result when a chemical (designated as R 833) having some repellent effect was sprayed on one half of the paper and comparison was made with sodium oleate solution on the other half. Under even illumination, 70 per cent repellency away from the repellent chemical was exhibited by the nymphs. When the sodium oleate-treated half was kept towards the side of greater light intensity, it was found that per cent

repellency rose from 70 to 81 as the illumination on one side was reduced to obtain a 10 foot-candle difference. As the light was further reduced on the half treated with repellent chemical, movement away from that side increased so that when the foot-candle difference was 20, the apparent repellency was 85 per cent and when the foot-candle difference

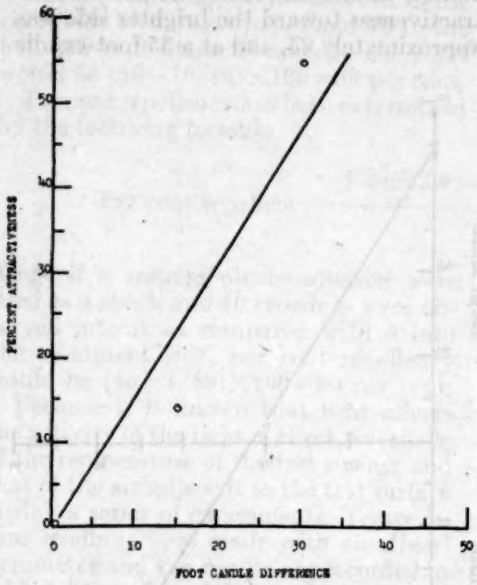

FIG. 6.—Attractiveness of light to adult ticks when both halves of test surface are untreated.

was 30, the apparent repellency was 90 per cent. In this experiment both the chemical, because of its repellent effect, and the brighter light on the opposite side, because of its attraction, caused the ticks to move toward the sodium oleate side.

On the other hand when the repellent chemical treated half was placed toward the side of greater light intensity, the per cent repellency dropped from 70 when the lights were uniform to 5 at 20 foot-candle difference (Fig. 5). When the foot-candle difference was increased to 30, the attraction of the light overcame the repellency of the chemical and a 40 per cent attractiveness toward the brighter side was obtained. At 35 foot-candle difference a 45 per cent attractiveness over the chemical was obtained.

OBSERVATIONS ON ADULT STAGE.—Although our preliminary repellency work is being conducted largely with nymphs, we wanted to know how the adults behave in relation to light. When both halves of

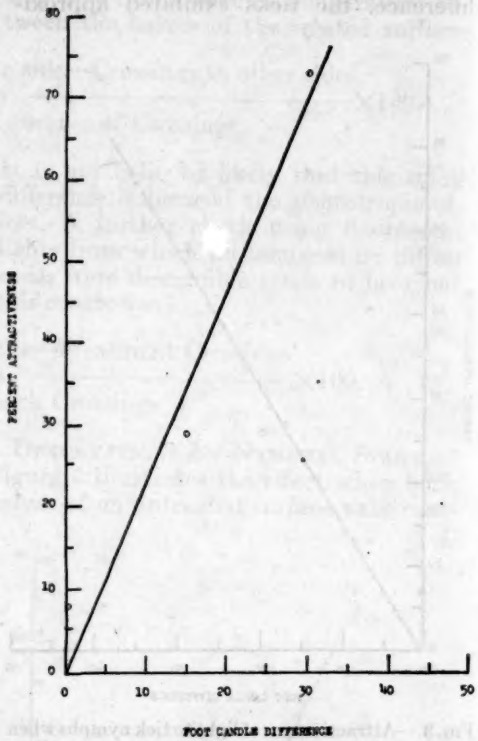

FIG. 7.—Attractiveness of light to adult ticks when both halves are treated with 1 per cent sodium oleate.

an untreated test surface were evenly illuminated, it was found that no preference was shown for either side (Fig. 6). However, when there was a 15 foot-candle difference, a 14 per cent attractiveness toward the brighter side was shown. This increased to 55 per cent attractiveness when the foot-candle difference was increased to 30.

Similarly when a 1 per cent sodium oleate solution was used to treat both halves of the test paper (Fig. 7), only a small percentage of adults showed any preference to one side over the other under even illumination. However, when the difference in illumination was 15 foot-candles, the percentage attractiveness toward the brighter light was 30 per cent. This increased to 55 per cent attractiveness toward the light when the difference between the two lights was 30 foot-candles.

When the repellent which had been used in the previous experiment with nymphs was employed for adults and compared with 1 per cent sodium oleate solution, it was found that under even illumination, the repellency was 49 per cent. Keeping the sodium oleate solution side towards the constant light and reducing the light on the half treated with repellent chemical (Fig. 8) resulted in a

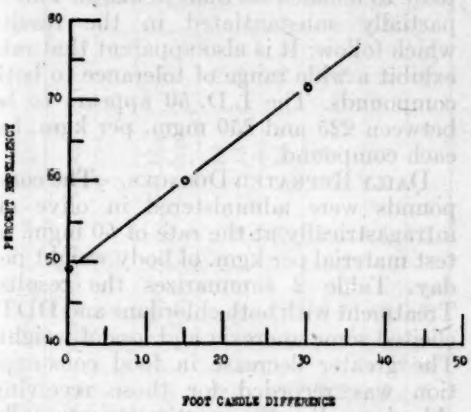

FIG. 8.—Effect of varying light intensity on adult ticks when one half of test surface is treated with a repellent chemical and the other half is treated with 1 per cent sodium oleate. The light intensity is decreased on the repellent half.

10 per cent rise in apparent repellency at a 15 foot-candle difference in illumination while at a 30 foot-candle difference, a 25 per cent rise in apparent repellency was obtained.

When the treated surface was turned so that the repellent chemical was toward the brighter side (Fig. 9), it was found that repellency dropped from 49 to 10 per cent at a 15 foot-candle difference in light. At a 30 foot-candle difference, the light again caused the ticks to overcome the repellent effect of the chemical.

DISCUSSION AND SUMMARY.—Repellency of various chemicals to ticks under laboratory conditions can be ascertained by applying the chemicals under test to a filter paper test surface. A band of the chemical may be sprayed to surround an inner untreated area on which ticks can later be placed to observe the number of crossings into the treated area over a period of time. By covering first one half of the paper prior to spraying and then the other half, two treatments may be

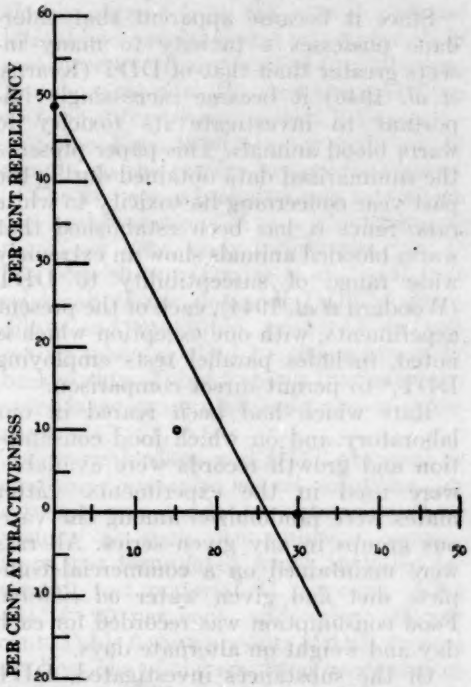

FIG. 9.—Conditions the same as in Fig. 8, except that the light intensity on the 1 per cent sodium oleate half was decreased.

applied to the same test surface and a direct comparison between the two can be obtained at the one time.

In the course of this work, it was observed that the ticks exhibited an attraction toward light. A series of experiments to illustrate this effect indicate that nymphs and adults are affected in proportion to the difference in light intensity within the range tested, from 5 to 40 foot-candles. When the treatments on both halves of the test surface were the same, each foot-candle difference in light, up to 30, resulted in approximately a 2 per cent attractiveness toward the side of greater light intensity.—11-21-46.

Toxicity of Chlordane[1,2] to White Rats

LESTER INGLE, *University of Illinois, Urbana*

Since it became apparent that chlordane possesses a toxicity to many insects greater than that of DDT (Kearns, *et al.* 1946) it became increasingly important to investigate its toxicity to warm blood animals. This paper presents the summarized data obtained during the past year concerning its toxicity to white rats. Since it has been established that warm blooded animals show an extremely wide range of susceptibility to DDT (Woodard *et al.* 1944), each of the present experiments, with one exception which is noted, includes parallel tests employing DDT,[3] to permit direct comparison.

Rats which had been reared in our laboratory and on which food consumption and growth records were available, were used in the experiments. Litter mates were randomized among the various groups in any given series. All rats were maintained on a commercial complete diet and given water *ad libitum*. Food consumption was recorded for each day and weight on alternate days.

Of the substances investigated, DDT was of the technical grade and chlordane employed in all experiments except those involving emulsions, was of reference grade (99 per cent pure). Chlordane used for emulsion tests was technical grade which represents a purity of from 90 to 92 per cent.

EXPERIMENTAL. SINGLE DOSE ACUTE TOXICITY. Experiments were conducted in an attempt to determine the acute oral toxicity of chlordane and to compare it weight for weight with that of DDT. The substances, dissolved in olive oil, were administered by a curved and blunted No. 18 needle attached to a syringe, and the test solutions were injected directly into the stomach. Dosages were administered according to the weight of the animals and adjusted so that the quantity of olive oil was the same for each rat.

Table 1 summarizes the results of several series. It will be noted that chlordane and DDT are apparently of the same order of acute toxicity, chlordane being slightly less toxic at the lower and the higher dose levels. There is also an indication that chlordane may be slightly more toxic to female rats than to males. This is partially substantiated in the results which follow. It is also apparent that rats exhibit a wide range of tolerance to both compounds. The L.D. 50 appears to be between 225 and 250 mgm. per kgm. for each compound.

DAILY REPEATED DOSAGES.—The compounds were administered in olive oil intragastrically at the rate of 50 mgm. of test material per kgm. of body weight per day. Table 2 summarizes the results. Treatment with both chlordane and DDT, elicited some anorexia and loss of weight. The greater decrease in food consumption was recorded for those receiving chlordane. For the most part, especially with the DDT treated rats, the greatest decrease in weight occurred within a two day period immediately prior to death, in some instances being equal to almost one third of the body weight. A majority of the rats exhibited symptoms of toxicity after the fourth dose. The two compounds appear to be about equally toxic to white rats under the conditions of the test. Female rats appeared to be more susceptible than males to chlordane.

WEEKLY REPEATED DOSAGES.—In order to receive some evidence of the recovery ability of rats which had received near-lethal dose levels of test materials, experiments were conducted in which rats received intragastric administrations at the rate of 75 mgm. of test materials per kgm. body weight on each of two consecutive days in each week. This allowed a 5-day recovery period between treatments. Results presented in table 3 again show the two compounds to be quite similar in toxicity to rats and also the range between the minimum lethal dosage level and the near maximum to be wide.

SUBLETHAL CHRONIC DOSAGES.—Table 4 shows the results of daily intragastric administrations of chlordane and DDT at the rate of 10 mgm. of per kgm. All animals survived the 120 day experi-

[1] *Velsicol 1068*, (1, 2, 3, 4, 5, 6, 7, 8-8 octochloro-4-7-methano 3a, 4-7-7a-tetrahydroandane).
[2] "Paid Paper."
[3] 2, 2-bis (p-chlorophenyl)-1, 1, 1-trichloroethane.

Table 1.—Acute toxicity of chlordane and DDT to rats. Single doses intragastrically.

		Mgm. Test Material per Kgm. Body Weight																	
		100		150		200		225		250		275		300		350	
		Chlordane	DDT	Chlordane	DDT	Chlordane	DDT	Chlordane	DDT	Chlordane	DDT	Chlordane	DDT	Chlordane	DDT	Chlordane	DDT
Died	Males	0	0	0	2	5	7	8	8	11	14	10	14	14	10	9	12
	Females	0	1	2	2	7	7	12	10	20	19	13	10	8	6	9	9
	Total	0	1	2	4	12	14	20	18	31	33	23	24	22	16	18	21
Survived	Males	14	14	16	14	14	12	13	13	18	16	10	6	3	5	3	0
	Females	13	13	16	14	14	14	11	13	10	11	7	10	8	6	3	3
	Total	27	27	32	28	28	26	24	26	28	27	17	16	11	11	6	3
Mortality o/o		0.0	3.6	5.9	12.2	30.0	35.0	45.5	40.9	52.5	55.0	57.5	60.0	66.7	59.3	75.0	87.5

mental period, although three DDT treated rats showed hyperexcitability and fine tremors between the 104th and 120th days, but which disappeared before the next daily treatment.

SKIN APPLICATIONS.—The hair was closely clipped from the rats dorsal and lateral body surfaces and test materials in measured quantities applied by inunction. For the most part, the area of application was the antero dorsal surface between the scapulae. Each application was allowed to remain on the rat for twenty-four hours.

The first series included only rats which received inunctions of pure chlordane, 50 mgm. per kgm. body weight per day. It has been shown (Draize *et al.* 1944) that relatively large doses of DDT powder, dilute and undiluted, produced no poisoning when applied to either intact or broken skin. Table 5 shows that rats survived large accumulative dosages of chlordane.

Since chlordane and DDT are used as emulsions and also as oil solutions, an attempt was made to determine their toxicity as such. An emulsion concentrate was formulated which included by weight, test material 25 per cent, *Atlox 1045A*, 20 per cent, and xylene 55 per cent. Table 6 shows results of daily topical applications of the emulsion concentrates at the rate of 75 mgm. of test material per kgm. body weight. Anorexia and loss of weight resulted soon after applications were initiated. No significant difference in toxicity between the two compounds was evident. Attention is again directed to the extremely wide range in susceptibility of rats to the two compounds.

The emulsion concentrates were then diluted with water and in one experiment (results summarized in Table 7) applied daily by inunction, 19 mgm. per kgm. of body weight and in the other (Table 8) at 1.5 mgm. per kgm. Since the volume employed was greater than in previous tests, it was necessary to maintain the rats in a position so they could not remove any of the dosage by mouth or by rubbing against the wire of the cages.

Chlordane treated rats numbers 361 and 362 of table 7 were killed for autopsy after the 126th day. Animal number 379 died with typical DDT symptoms after the 103rd day. There was little evidence of interference by the treatments with food consumption or weight increments.

Table 2.—Daily intragastric administration of chlordane and DDT. 50 mg. per kgm. body weight.

Chlordane					DDT				
Rat No. and Sex	Doses Survived	Total Dosage mgm./kgm.	Initial Weight Grams	Final Weight	Rat No. and Sex	Doses Survived	Total Dosage mgm./kgm.	Initial Weight Grams	Final Weight
69–	5	250	230	209	82–	5	250	235	195
73–	5	250	236	220	79–	5	250	235	178
77–	5	250	241	227	83–	6	300	230	210
75–	6	300	230	212	86–	7	350	241	220
70–	7	350	239	197	87–	7	350	236	195
76–	7	350	235	222	88–	10	500	238	194
72–	8	400	226	210	85–	10	500	235	203
74–	8	400	242	221	81–	11	550	244	185
78–	9	450	244	235	80–	11	550	221	188
71–	10	500	235	220	84–	30	1500	337	272

Rats receiving inunctions as shown in table 8 exhibited no signs of anorexia or loss of weight. All survived the 147-day experiment.

Results summarized in Table 9 show the effects of skin applications of chlordane and DDT dissolved in refined kerosene (deobase). Inunctions of 25 mgm. per kgm. per day of test materials showed little effect on food consumption or weight increases over the 65 day period. However, 50 and 75 mgm. per kgm. applications did result in loss of appetite and decrease in weight increments. The toxicity was quite similar for the two compounds.

Discussion.—When administered intragastrically in olive oil and topically as emulsion concentrates, emulsions and oil solutions, chlordane appears to be of about the same degree of toxicity to white rats as DDT. Of the DDT treated

Table 3.—Toxicity of intragastric administration of chlordane and DDT, 75 mgm. per kgm. on each of two consecutive days each week.

Rat No. and Sex	Number of Weeks	Dosages Survived	Total Dosages, mgm./kgm.	Total Dosage, mgm.	Initial Weight, Grams	Final Weight, Grams
Chlordane						
41–	3	6	450	104.9	233	203
48–	4	8	600	96.6	161	183
43–	4	8	600	91.2	152	174
42–	5	10	750	165.0	220	244
45–	5	10	750	291.0	388	377
49–	5	10	750	118.5	158	191
47–	6	12	900	201.6	224	259
46–	7	14	1050	226.8	216	212
44–	17	34	2550	372.3	146	182
40–	17	34	2550	525.3	206	296
DDT						
51–	1	2	150	33.3	222	166
53–	3	6	450	71.1	158	143
56–	3	6	450	167.4	372	346
52–	4	8	600	135.6	226	204
54–	4	8	600	97.2	162	171
58–	4	8	600	84.0	140	146
59–	4	8	600	86.4	144	139
57–	6	12	900	227.7	253	250
50–	17	34	2550	167.7	203	241
55–	17	34	2550	629.9	247	322

rats which died, typical symptoms were observed, namely, a decrease in food consumptions, loss of weight, hyperexcitability, increase in respiratory rate, pronounced tremors and occasionally clonic convulsions. Symptoms of toxicity by chlordane were qualitatively quite similar to those produced by DDT. The primary differences were quantitative in that tremors and clonic convulsions were more severe for chlordane-treated rats. The convulsions lasted for only a minute or two and appeared at intervals of about 20 to 30 minutes. However, they could be induced by mechanical or auditory stimuli. Death frequently but not always resulted during a seizure. A marked increase in respiratory rate was noted within a few minutes after applications of chlordane.

Another difference between the effects of the two compounds was the time lapse between an acute lethal dose and death.

Table 4.—Effects of intragastric administration of chlordane and DDT on weight increases. 10 mgm. per kgm. of body weight daily for 120 days.

No. of Rats and Sex	Av. wt. grams	
	initial	final
Chlordane		
15	152	228
15	203	283
Controls		
15	156	241
15	195	291
DDT		
15	151	234
15	212	301

Table 5.—Percutaneous inunction of pure chlordane, 50 mgm. per kgm. per day.

Rat No. and Sex	Initial Weight, Grams	Final Weight, Grams	Dosages Survived	Total Dosage, mgm./kgm.	Total Dosage, mgm.
332–	151	150	60	3000	450
331–	145	195	83	4150	598
333–	148	194	90	4500	666
334–	150	186	95	4750	713
335–	165	201	125	6250	1031
336–	172	226	129	6450	1109
330–	170	197	142	7100	1207
329–	149	315	150	7500	1125

Table 6.—Percutaneous inunctions of chlordane and DDT as emulsion concentrate. 75 mgm. per kgm. per day.

Rat No. and Sex	Initial Weight, Grams	Final Weight, Grams	Dosages Survived	Total Dosages, mgm./kgm.	Total Dosages, mgm.
Chlordane					
372–	195	158	7	525	101.5
374–	177	139	7	525	92.8
373–	285	222	7	525	148.8
373–1–	240	209	7	525	126.0
374–1–	194	174	8	600	116.4
374–2–	182	164	8	600	109.2
371–	302	285	56	4200	1262.8
375–	235	295	147	11,025	2852.5
DDT					
389–	155	105	5	375	58.1
388–	183	140	5	375	68.6
387–	211	181	6	450	95.0
387–1–	210	175	6	450	95.5
388–1–	191	156	6	450	86.0
390–	189	300	68	5100	964.0
389–	162	232	72	5400	875.0
386–	269	365	147	11,025	2965.7

Table 7.—Percutaneous inunctions of chlordane and DDT. Emulsion concentrate diluted 1–67 and applied at rate of 19 mgm. per kgm. body weight.

Rat No. and Sex	Initial Weight, Grams	Final Weight, Grams	Dosages Survived	Total Dosage, mgm./kg.	Total Dosage, mgm.
Chlordane					
361	255	315	126	2394	610
363	287	418	147	2793	802
365	213	283	147	2793	595
362	191	228	126	2394	457
364	201	225	147	2793	562
DDT					
376	217	295	147	2793	606
378	245	299	147	2793	684
380	275	366	147	2793	768
377	184	226	147	2793	514
379	188	165	103	1957	368

Table 8.—Percutaneous inunction of chlordane and DDT. Emulsion concentrate diluted 1 to 830 and applied at rate of 1.5 mgm. per kgm. body weight.

Rat No. and Sex	Initial Weight, Grams	Final Weight, Grams	Dosages Survived	Total Dosages, mgm./kgm.	Total Dosage, mgm.
Chlordane					
366	221	307	147	220.5	49
368	219	335	147	220.5	48
370	234	360	147	220.5	52
367	198	240	147	220.5	44
369	173	247	147	220.5	38
DDT					
381	253	351	147	220.5	56
383	238	363	147	220.5	53
385	255	369	147	220.5	56
382	230	242	147	220.5	51
384	200	227	147	220.5	44

The peak of mortality for DDT treated rats occurred within the first 24 hours while that of chlordane treated animals occurred during the fourth day after administration. If rats survived the first 24 to 36 hours after a single dose of DDT, they usually continued to live but several rats which received acute single dosages of chlordane did not die until from 2 to 3 weeks following administration. Their symptoms were those typical of chlordane.

Table 9.—Percutaneous inunction of chlordane and DDT in *Deobase*.

Rat No. and Sex	Initial Weight, Grams	Final Weight, Grams	Dosages Survived	Total Dosage, mgm./kgm.	Total Dosage, mgm.
Chlordane 25 mgm. per kgm.					
271	443	462	65	1625	751
273	126	233	65	1625	205
272	152	298	65	1625	247
274	110	199	65	1625	179
275	124	186	65	1625	202
DDT—25 mgm. per kgm.					
286–	448	448	65	1625	728
287	126	296	65	1625	205
288	148	255	65	1625	241
289	148	213	65	1625	241
290	119	193	65	1625	195
Chlordane—50 mgm. per kgm.					
280–	120	124	12	600	72
277–	149	166	12	600	89
279–	118	133	13	650	77
278–	162	335	65	3250	527
276–	404	440	65	3250	1307
DDT—50 mgm. per kgm.					
294–	140	143	7	350	49
292–	158	161	10	500	79
291–	363	328	65	3250	1170
293–	168	289	65	3250	546
295–	124	207	65	3250	403
Chlordane—75 mgm. per kgm.					
282	168	151	5	375	63
284	126	121	7	525	66
285	124	115	7	525	65
283	161	168	10	750	121
281	374	332	12	900	337
DDT—75 mgm. per kgm.					
300	119	100	5	375	45
297	148	150	7	525	78
298	187	179	8	600	112
296	363	327	10	750	272
299	141	209	65	4875	689

Gross pathological findings for rats inuncted with chlordane or DDT showed varying degrees of hyperkeratosis with some roughening or brownish discoloration and evidence of ulceration. Autopsy of animals dying as a result of the test material showed considerable liver damage due to DDT, but very little damage as a result of chlordane. The damage is characterized by pallor and occasional centrolobular darkening. Evidence of kidney pitting and hemorrhage was noted in animals of both test groups. Chlordane produced more pulmonary damage than did DDT as evidenced by edema and bronchial hemorrhage.

The histological findings are not as yet complete but at present it appears that Chlordane, administered orally or topically produced less liver damage but greater pulmonary damage than DDT.

SUMMARY.—Chlordane and DDT, compared weight for weight, appear to be of the same order of toxicity to white rats, when administered as acute and repeated intragastric dosages and when inuncted percutaneously as an oil solution, emulsion concentrate and dilutions of the emulsion concentrate.

Rats receiving either chlordane or DDT present a wide range of individual susceptibility, which makes it difficult to establish an absolute minimum or median lethal dose.

Anorexia, loss of weight, hyperexcitability, and tremors were symptoms produced by both compounds. Tonic and clonic contractions were slightly more severe for those treated with chlordane.

The time lapse between administration of an acute lethal dose and death is longer for chlordane than for DDT treated rats.

There is some indication that chlordane may be slightly more toxic to female rats than to males. This was not observed to be true for DDT treated rats.

Chlordane appears to produce in rats less liver damage but greater pulmonary damage than DDT.

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DDT, Benzene Hexachloride and Chlordane for Japanese Beetle Control[1]

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During the past summer comparative studies on the relative efficiency of DDT, benzene hexachloride, and chlordane for controlling the Japanese beetle were made. All three of the insecticides were found to be effective for killing beetles. With the formulations used there were, however, differences in the speed of knockdown, residual effect and repellent value.

With formulations diluted to contain equal amounts of insecticide, the emulsions of DDT and benzene hexachloride gave faster knockdowns than water suspensions, but water suspensions appeared more effective for residual kill and lasting repellency. In water suspension benzene hexachloride gave a more rapid knockdown than a similar suspension made up with DDT. Chlordane as an emulsion was not as effective as either DDT or benzene hexachloride from the standpoint of either knockdown or residual effect.

MATERIAL USED.—In these studies all data are based on results obtained by using dilutions that contained 1 pound of the actual chemical in 100 gallons of water. Two types of formulations were used; namely, emulsions and formulas containing 50 per cent of the technical chemical and prepared for use as a water suspension. Emulsions were prepared by dissolving 20 parts by weight, of the technical chemical in 60 parts of xylene and then adding 20 parts of an emulsifier.[2] The benzene hexachloride was a technical product containing 10 per cent gamma isomer and was furnished by the du Pont Company.

The data reported for water suspensions were from 50 per cent wettable DDT[3] and 50 per cent wettable benzene hexachloride (5 per cent gamma isomer).[4] The source of the materials used for the water suspensions is emphasized because the writers found that there was variation in the speed of knockdown and residual effect between formulas prepared for use as water suspensions from different sources. It is not known whether these differences are the result of mixing or of differences in formulation. Limited tests by the writers, with laboratory formulations, did indicate that the carrier or diluent could be a factor.

Results reported for laboratory observations on knockdown studies and relative toxicity of freshly dried residues are average figures and based on data obtained from the use of 10 insects, replicated 10 times, and repeated a minimum of 7 times on different days. Thus the data for each material represents observations on a minimum of 700 insects.

FIELD TESTS.—Comparative tests in commercial orchards indicated that all three insecticides could be used to protect foliage and ripening peaches and apples. Sprayed fruit and foliage was freed of beetles; dead and dying beetles were abundant in the sprayed plots, and repellency to sprayed foliage was obvious. But there were distinct differences in the rate at which beetles fell from the trees and the rate at which they died. The writers, as well as the growers, cooperating in the tests were decidedly impressed with these differences.

Field observations clearly showed that the most rapid knockdown came from the DDT and benzene hexachloride emulsion, followed by benzene hexachloride suspensions and DDT suspensions. *Velsicol 1068*[4] was quite slow and less spectacular.

In an attempt to gather information on the relative differences in speed of knockdown for the several insecticides and formulations, laboratory tests were made. Tests based on wetting beetles by dipping for 5 seconds in the insecticide and then immediately drying on blotting paper, after which they were removed to clean cages, showed the average knockdown time for such treatment to be as follows:—DDT emulsions 10.5 minutes, benzene hexachloride emulsions 16.7 minutes, DDT suspensions 27.8 minutes and benzene hexachloride suspensions 24.8 minutes. *Velsicol 1068* was much slower. Two to 4 hours after dipping often failed to give total knockdown.

REPELLENCY AND TOXICITY OF DRIED

[1] Eastern Branch Program.
[2] *Triton* ×100.
[3] Manufactured by the General Chemical Co.
[4] Furnished by E. I. du Pont de Nemours Co., Inc.

RESIDUES.—As already noted, repellent value was obvious for all three insecticides. The period of protection varied considerably. In the areas of these experiments the weather was cool and wet. This was conducive to rapid plant growth which, combined with heavy beetle populations, resulted in a rapid return of beetles to all sprayed plants. Regardless of the material or formulations used, beetles returned to new and unsprayed growth in from 4 to 10 days. With returning beetles congregating on new foliage it was difficult to determine with exactness the relative repellent value for the different materials. On the basis of a day to day examination of the number of beetles resting on both sprayed and unsprayed foliage DDT and benzene hexachloride as water suspensions showed more lasting repellency than that of the emulsions of these materials or of chlordane. Trends indicated that DDT as a water suspension was possibly slightly more lasting than benzene hexachloride in the same form.

All three chemicals in the form of dried residues on foliage were toxic to Japanese beetles. In the field, this toxicity was evidenced by the fact that beetles were observed dying on and under treated foliage for 6 to 10 days after spraying.

In order to determine the relative efficiency of residues from the different materials as well as that of different formulations, laboratory tests were made. These tests showed that residues from the water suspensions were much more potent and lasting than those obtained from the emulsions. With beetles exposed for 1 minute on freshly dried residues, obtained by dipping leaves in the spray solutions, benzene hexachloride in a water suspension gave the best kill. At the end of a 24 hour period the percentage control for the several materials were as follows: Benzene hexachloride suspension 99.5; DDT suspension 95.8; benzene hexachloride emulsion 70.8; DDT emulsion 57.5 and chlordane 50.9.

Studies on the lasting toxicity of dried residues under field conditions were made by using leaves collected at random from field sprayed grapes. Toxic value for each residue was determined by exposing a total of 100 beetles to 10 different leaves in lots of 10 beetles to each leaf.

The results obtained showed variation for individual leaves, but average figures showed that the toxic value of a residue decreased as the residues weathered and aged. Further, the rate at which beetles were overcome or died followed very closely the period of time they were exposed to the residue.

At the end of 15 days, during which period it rained on four occasions, the residues from all the materials, with the exception of the water suspension of benzene hexachloride on which data was not collected, showed toxicity when beetles were exposed continuously for 24 hours on sprayed leaves. But only the residues from the water suspensions of DDT gave repeated high average kills. The kill for this material averaged 91.6 per cent for the 15-day period. The residues from the emulsions were not nearly so efficient or lasting. On the basis of exposing beetles to sprayed foliage for 5 minutes, the results from the deposits laid down by the emulsions became very inefficient and erratic after the third day. The mortalities on the average dropped to less than 30 per cent. The water suspension of DDT gave a mortality in excess of 90 per cent through the sixth day. 11-21-46

Evaluation of Pyrophyllite as an Insecticide Diluent[1,2]

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Pyrophyllite is a widely used diluent for insecticide powders. It was an adjunct to the use of DDT against lice in the recent war, when many tons of American pyrophyllite were scattered over the world. Before that time pyrophyllite was well known in the agricultural field. Despite its popularity, the merits of this diluent have been a matter of controversy. The purpose of this paper is to point out some

[1] This research was conducted as part of a program supported by transfer of funds from the Office of the Quartermaster General, U. S. Army, to the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.
[2] Eastern Branch Program.

precautions that should be taken in standardizing pyrophyllite in order to make proper comparisons with other diluents.

Pyrophyllite is a hydrous aluminum silicate, $H_2O \cdot Al_2O_3 \cdot 4SiO_2$, formed by hydrothermal alterations of volcanic deposits. It has been reported as occurring in various parts of the world—Belgium, Switzerland, Luxembourg, Sweden, Russia, China, Japan, and Brazil, and, within our own country, in Pennsylvania, North and South Carolina, Georgia, and California. In its general nature this mineral is similar to both talc and clay, physically perhaps more like talc but chemically more like a typical clay. Its economic history in this country goes back at least 90 years (Stuckey 1925). In fields other than that of insecticides it has been used for face powder, crayons, firebrick, and gravestones, and in the manufacture of paper, rubber, soap, roofing, paint, and pottery.

Standardization of pyrophyllite for experimental purposes is somewhat difficult, because the mineral as found in nature is often very impure. Among the other minerals associated with are quartz, various micas, pyrite, feldspar, alunite, andalusite, corundum, diaspore, kyanite, lazulite, and iron oxides (Dana 1932; Kerr 1932, Stuckey 1925). Sometimes a commercial nominal pyrophyllite contains little or no true pyrophyllite. More often it does consist mainly of the designated mineral, but contains a high percentage of impurities, notably quartz. From 25 to 30 per cent of quartz is considered not uncommon. This accounts for the abrasiveness found in commercial pyrophyllite; the pure mineral is barely harder than talc, which is accepted as the softest of all known minerals.

Because of these uncertainties of composition, in assembling materials for experiments to evaluate pyrophyllite in relation to other insecticide diluents, the following precautions must be observed.

1. Be sure that the material designated as pyrophyllite is not some very different material. One or more varieties of mica, for example, have passed as pyrophyllite.

2. Take special care to distinguish between pyrophyllite and talc. These two minerals are easily confused. Both occur in foliated, fibrous, granular, and compact varieties. Both feel greasy to the fingers. They have the same negative optical character. Quantitative properties, both optical and mechanical, in which the two minerals are similar appear in table 1.

Table 1.—Some physical similarities between pyrophyllite and talc.

REFRACTIVE INDICES:	PYROPHYLLITE	TALC
Alpha	1.55	1.54
Beta	1.59	1.59
Gamma	1.60	1.59
Density, grams per cubic centimeter	2.8–2.9	2.7–2.8
Hardness	1–2	1–1.5

The chemical composition of talc is that of pyrophyllite with the substitution of magnesium for aluminum (3 atoms of the former to 2 of the latter), and the crystal lattice spacings of the two minerals are so much alike as to cause possible confusion in distinguishing between the two by X-ray diffraction (Table 2). After it has been established that the same under investigation is either pyrophyllite *or talc*, and if it proves too difficult to differentiate between the two by physical means, the question can be settled by a chemical test to distinguish between aluminum and magnesium. A simple one is the well-known mineralogist's blowpipe test with cobalt nitrate solution. This test, while not satisfactory for general use, fortunately does work well for the two minerals here considered.

Table 2.—X-ray diffraction data (from Gruner 1934).

UNIT-CELL CONSTANTS:	PYROPHYLLITE	TALC
Number of molecules	4	4
Cell dimensions and axial angles	(Corresponding quantities differ by less than 3%)	
Axial ratio	0.58:1.00:2.08	0.58:1.00:2.07
Theoretical density, grams per cubic centimeter	2.84	2.82
Lattice spacings (angstroms) for the 5 theoretically strongest diffraction lines	2.41	2.46
	1.63	1.66
	1.48	1.52
	1.36	1.38
	1.26	1.29

3. Do something about the quartz content. The purpose here is not to say whether quartz is desirable or undesirable as an ingredient of insecticide diluents. In research, however, for the purpose of com-

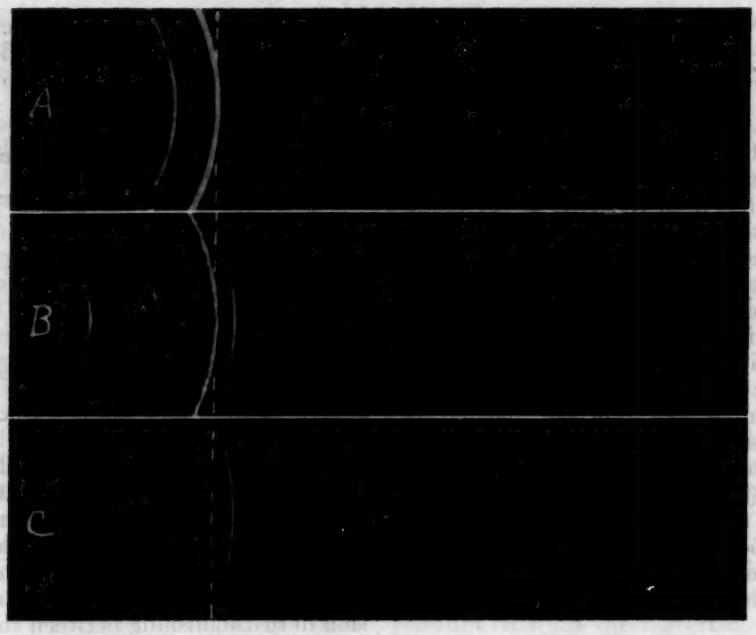

FIG. 1.—X-ray diffraction patterns demonstrating quartz in pyrophyllite. Upper, Quartz; Middle, a commercial pyrophyllite, insecticide grade; Lower, refined pyrophyllite, with merely a trace of quartz. The dotted line marks the position of the principal quartz line.

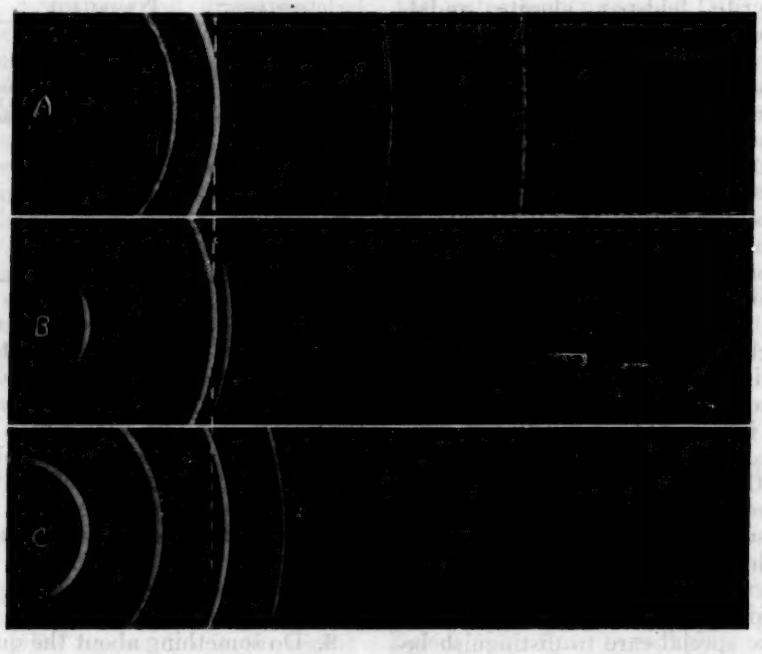

FIG. 2.—X-ray diffraction patterns showing variation of quartz content in talc. Upper, Quartz; Middle, an insecticide-grade talc; Lower, talcum powder, U.S.P. The dotted line marks the position of the principal quartz line.

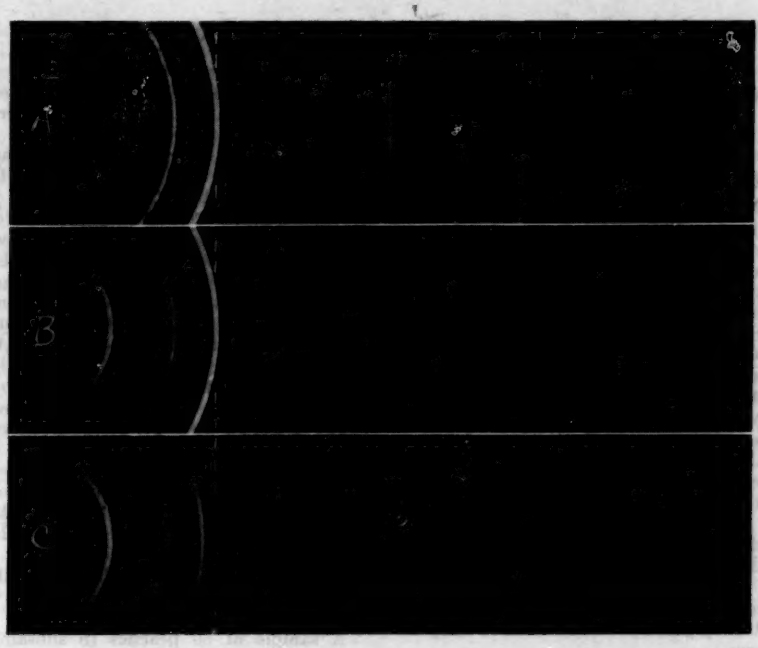

FIG. 3.—X-ray diffraction patterns showing variation of quartz content in kaolin. Upper, Quartz; Middle, kaolin, N.F.; Lower, an insecticide-grade kaolin. Note that the less expensive product (C) appears to have the higher purity.

paring candidate materials, it would be inconsistent, for example, to study pyrophyllite versus talc, or kaolin, or both, using in some cases a substantially pure mineral species, and in others an indefinite mixture. The three minerals named are all obtainable both with high quartz content and practically quartz-free. The United States Bureau of Mines has developed an economical process for removal of quartz from pyrophyllite by flotation.[1] The refined pyrophyllite, the X-ray diffraction pattern of which is shown in figure 1, is a product of this process, and the quartz powder, the pattern of which is used for reference in all figures, is a laboratory preparation; the other diffraction patterns shown in this paper are from commercial products (Figs. 2 and 3).[2]

Therefore, in any critical research designed to evaluate pyrophyllite as an insecticide diluent, precautions should be taken to ensure that the material used is actually pyrophyllite, of a reasonably pure grade. Any reference minerals used should be of similar grade, particularly with regard to quartz content.

[1] Lamb, unpublished work.

[2] Acknowledgement is made to Robert L. Updike, Jr., and George I. Poos for assistance in the X-ray analyses.

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SCIENTIFIC NOTES

New Insecticides for Control of the Oriental Fruit Moth

W. P. YETTER, JR., *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During 1945 DDT spray tests for the control of the oriental fruit moth, *Grapholitha molesta* (Busck), were conducted in two commercial peach orchards at Moorestown, N. J. Only one spray was applied to each group of test plots in each orchard. The oriental fruit moth infestation on the fruit at harvest-time in both orchards was so light, 2.5 per cent in the check plots and 2.0 per cent in the sprayed plots, that no conclusion as to the efficiency of DDT could be reached. In 1946 DDT was used in two orchards and the methoxy analog of DDT in a third. The tests were designed to determine whether a single spray of either of these materials applied against the third-brood larvae about 3 weeks before harvest would be effective in reducing the amount of ripe-fruit injury. It was also desirable to find out whether the one spray would be followed by a heavy build-up of mites, would avoid the risk of leaving a spray residue higher than the accepted tolerance, and whether it might provide a control measure supplementary to natural control by parasites rather than in competition with them.

PLOT ARRANGEMENT.—Each experimental block was composed of 2 rows of 9-tree plots.

In orchard 1 a block of Summercrest trees, 8 rows wide and 36 long, running along the entire east side of the orchards was used. The 14 plots were so arranged that each plot was separated from the others by 2 rows of trees (Fig. 1). Every other test plot was sprayed while the alternate plots were used as checks.

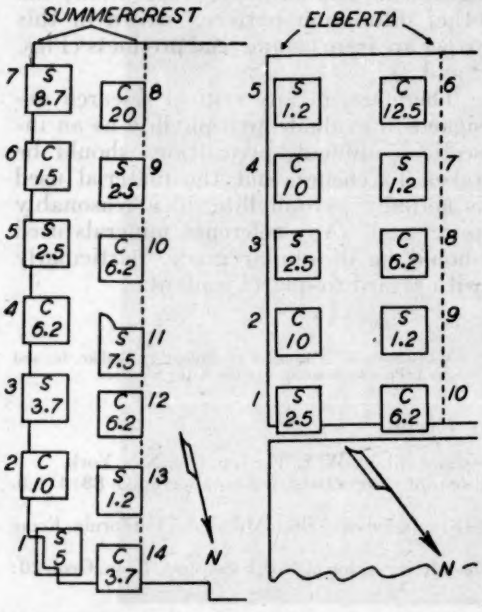

FIG. 1.—Plot arrangement used for orchard 1. (Left), and Orchard 2 (Right). The odd-numbered (S) plots were sprayed while the even-numbered (C) plots were used as checks. Figures within the plots indicate per cent of wormy fruit.

Orchards Nos. 2 and 3 followed the same general plot arrangement except that orchard 2, the Elberta block, had 10 plots and orchard 3, the After-Glow block, had 14. In orchard 2 the plots were separated by 2 rows of trees in the north-south direction and 4 rows in the east-west direction; in orchard No. 3 they were, generally, 3 rows apart in the north-south direction and 2 in the east-west direction.

MATERIALS AND METHODS.—A commercial wettable powder stated to contain at least 16 per cent of DDT and 20 per cent of the acaricide hydroxypentamethylflavan (technical) was applied as a spray in orchards 1 and 2. This material was used at the rate of 5 pounds per 100 gallons (actual DDT, 0.8 pound; flavan acaricide, 1 pound). In orchard 3 a commercial wettable powder stated to contain at least 50 per cent of the methyoxy analog of DDT (dimethoxyphenyl trichloroethane) (technical) was used at the rate of 2 pounds per 100 gallons (actual methoxy analog of DDT, 1 pound).

The spray was applied by the writer with a tractor sprayer, and all the spraying was done with a gun from the ground.

A sample of 80 peaches (8 subsamples of 10 peaches each) picked at random was taken from each sprayed and unsprayed plot at harvest time.

RESULTS.—The effectiveness of the spray in each orchard as determined by comparing the percentage of wormy peaches in the sprayed and the unsprayed plots, is summarized in table 1. The percentages for the individual plots are shown in figure 1. The effect of the spray on the build-up of mites, as determined by making examinations of foliage 3 times within 30 days after spraying, is shown in table 2.

DISCUSSION.—Statistical analysis shows that in orchard 2 the difference in worminess between the check plots and those sprayed with DDT-flavan was highly significant. The difference was not significant in orchard 1, which received the same treatment, or in orchard 3, which was sprayed with the methoxy analog of DDT. The differences were all in the same direction, however.

In orchard 1 the worminess in the sprayed plots was less than that in the nearest check except in two plots; sprayed plot 11 was slightly wormier than the check plots 4, 10 or 12, and sprayed plot 1 was slightly wormier than plot 14. In figure 1 it will be noted that every sprayed plot in orchard 2 had less wormy fruit than the nearest checks.

No injury to fruit or foliage occurred in any of the plots.

The summer of 1946 was dry and hot enough to be ideal for mite development, but very few mites were noted at the time of spraying, there being less than 1 mite per leaf in all plots. In 10 to 14 days after spraying a slight increase was noted in all plots. A month after spraying, mites could be found on most of the foliage but not in large enough numbers to be considered serious. The mite population probably would have been higher than indicated in table 2 had not several driving rains occurred during the last half of August which no doubt washed off and destroyed many of the crawling mites. There seems to be no doubt that a substantial build-up on the DDT-flavan sprayed foliage did take place in spite of the acaricide which was included with the spray.

Table 1.—Comparison of per cent of wormy fruit in plots sprayed with DDT or methoxy analog of DDT and in unsprayed plots.

Orchard No.	Spray	Date of Spray	Average Per Cent Wormy Fruit		Estimated Per Cent Control
			Check Plots	Sprayed Plots	
1	DDT plus flavan	July 24	9.6	4.5	53
2	DDT plus flavan	26	9.0	1.8	80
3	Methoxy analog of DDT	26	13.9	9.6	31

Table 2.—Mite counts on sprayed and unsprayed peach foliage in orchards. (50 leaves examined in each count.)

Orchard No.	Spray	Date of Spray	Date of Counts	Mites per Leaf	
				Sprayed Plots	Unsprayed Plots
1	DDT plus flavan	July 24	July 31	0.08	1.0
			Aug. 6	1.58	1.06
			26	8.48	5.96
2	DDT plus flavan	July 26	Aug. 6	1.24	1.41
			9	.98	1.68
			27	19.10	6.58
	Average of two orchards		Aug. 26–27	13.7	6.2
3	Methoxy analog of DDT	July 26	Aug. 2	.46	.46
			8	.92	.46
			27	10.48	3.34

The amount of DDT spray residue on fruit for human consumption is important. An analysis[1] of the DDT residue on fruit from orchard 1 was made 1 day after spraying and again 3 weeks later, or just before harvest. The analysis 1 day after spraying showed a residue of DDT of 15.1 p.p.m., but at harvest time it was only 2.85 p.p.m., as compared with the accepted tolerance of 7 p.p.m.

SUMMARY.—Two peach orchards at Moorestown, N. J., were sprayed for the control of the oriental fruit moth, *Grapholitha molesta* (Busck), about 3 weeks before harvest in 1946 with a commercial preparation stated to contain 16 per cent of DDT and 20 per cent of hydroxypentamethylflavan, at the rate of 5 pounds per 100 gallons. The result was an estimated reduction of 53 per cent in one instance and 80 per cent in the other, the second of which was highly significant. One orchard sprayed about 3 weeks before harvest with a commercial preparation stated to contain 50 per cent of the methoxy analog of DDT (di(methoxyphenyl) trichloroethane) at the rate of 2 pounds per 100 gallons of spray, showed 31 per cent less worminess than the checks, which in this experiment was not enough to be significant.

The estimated control of the oriental fruit moth resulting from the use of the DDT-flavan spray was good, and no spray injury to fruit or foliage was detected. The residue at harvest time in one orchard was well below the accepted tolerance of 7 p.p.m. No serious mite build-up developed.—12-13-46.

[1] By Chisholm & Koblitsky of the Insecticide Division of the Bureau of Entomology and Plant Quarantine at Moorestown, N. J. laboratory.

Results from Feeding Mosquito Larvae, Killed by DDT, to Goldfish[1,2]

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Toxicological tests conducted during the last few years with DDT, $(C_6H_4Cl)_2CHCCl_3$ have shown this compound to be very highly toxic to mosquito larvae and fish (Ginsburg 1945), as well as to many other forms of aquatic life upon which fish may feed (Hoffman *et al.* 1946). Of the DDT isomers tested the P,P′-isomer, 1-trichloro-2,2-bis (p. chloro phenyl ethane) proved highest in toxicity, giving 100 per cent dead larvae of *Culex pipiens* and *Aëdes aegypti* at dilutions of 1 part per 20 million, within 48 hours and 100 per cent dead goldfish at dilutions of 1 part to 5 million parts of water after 5 days. On account of its toxic effect on fish, the usefulness of DDT in mosquito control is at present limited to waters where no danger of poisoning fish exists.

In the course of experiments with DDT isomers and analogs on mosquito larvae and goldfish, the writer became interested in finding out whether dead mosquito larvae, killed by DDT, will retain enough of the toxicant in their bodies to poison fish should the latter drift into the treated areas and feed on them. With this objective in mind, larvae of *Aëdes aegypti* dead from DDT treatments were fed to goldfish, *Crassius auratus*.

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, Department of Entomology.
[2] Eastern Branch Program.

MATERIALS AND METHODS.—The goldfish, 6 to 9 months old, were secured from a commercial fish hatchery. The mosquito larvae were raised in the laboratory and were nearly uniform in size. Ethanol solutions of both technical grade DDT and pure, P,P'-DDT isomer were employed for killing the larvae. About 50 to 60 fourth-instar larvae were kept in beakers each containing 200 cc. of distilled water. One cc. of ethanol containing various concentrations of the toxicants, depending on the dilution in parts per million desired, was dispersed in each beaker. Previous tests showed that this small quantity of ethyl alcohol alone (approximately 0.5 per cent of the total volume), had no effect on the larvae. At the end of 48 hours the dead larvae were removed from the test beakers, washed with distilled water, again transferred to beakers of distilled water and stored in the refrigerator at approximately 38°F. At this temperature the dead larvae can be kept without decomposition for long periods of time. The dead larvae stored for testing were taken only from those concentrations, of either P,P'-DDT isomer or technical DDT which gave 100 per cent mortality within 48 hours. These concentrations ranged from 1 to .05 PPM.

Table 1.—Effect of DDT killed mosquito larvae on goldfish.

Test Jar No.		No. of Goldfish	Larvae Fed Daily	Number of Fish Dead After 3 days	4 days	14 days
DDT Test Fish	1	2	50 dead larvae	0	0	0
	2	2	50 dead larvae	0	0	0
	3	2	50 dead larvae	1	0	0
	4	2	50 dead larvae	0	0	0
	5	2	50 dead larvae	0	0	0
	6	2	50 dead larvae	0	0	0
Check Fish	7	2	50 live larvae	0	0	0
	8	2	50 live larvae	0	0	0

TESTS ON GOLDFISH.—The tests were conducted under laboratory conditions in glass jars, each containing 2000 cc. of water and two fish. About 50 dead larvae were added daily to each of six test jars during four successive days. To two other test jars, which served as checks, 50 live larvae were added daily during the same period. In each case the larvae were readily eaten, giving an average of approximately 100 larvae per fish. On the fifth day, the surviving test-fish and the four check-fish were transferred to two separate aquaria of about 6 liters capacity and kept under observation for 10 days longer. During this last period small quantities of fish food were added daily to the aquaria and the water was changed twice.

RESULTS.—No differences were observed in the appetite of the fish for either dead or live larvae. In each case all the larvae placed in the jars were devoured every day. The data tabulated in table 1 show the following: Of the twelve fish fed on DDT-dead larvae, only one died on the third day. None of the four fish fed on live larvae died. Since in previous tests with goldfish under laboratory conditions, as high as 10 per cent mortality of the check fish often occurred within a testing period of 5 days, and since none of the eleven fish which survived the test died during the subsequent 10-days under observation, the writer is inclined to ascribe the death of the one fish to natural causes rather than to DDT.

The non-poisonous effect of DDT-killed larvae to fish may be explained by one of the following assumptions: Either the larvae do not take in enough DDT before death to become toxic to fish, or the DDT is decomposed within the bodies of the larvae with the resultant loss of its toxic properties.

CONCLUSION.—The results suggest the following two conclusions: First, goldfish may feed just as readily on dead as on live mosquito larvae. Second, mosquito larvae killed by DDT are not poisonous to goldfish.

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Organic Insecticides for the Lesser Migratory Locust

A. W. A. BROWN and H. HURTIG, *Experimental Station, Suffield, Alberta, Canada*

A programme of research on grasshopper control by oil sprays from aircraft and by oil aerosols from steam generators has been initiated as a cooperative project between the Division of Entomology, Dominion Government, and the Experimental Station, Suffield. As a preliminary to field work, laboratory tests were made with oil solutions of five of the most powerful organic insecticides in production, namely DDT, benzene hexachloride, DNOC, chlordane and phenothiazine. The insects tested were last stage nymphs and young adults of the lesser migratory locust, *Melanoplus m. mexicanus*, both stages showing the same degree of susceptibility.

The insecticides were dissolved in oil mixtures consisting of xylene, kerosene, acetone, fuel oil and others in varying proportions as dictated by their solubilities. The oil sprays were applied by means of a *DeVilbiss* nasal atomizer into the standard Peet-Grady chamber, the biological material being exposed at a point on the floor where the average diameter of the falling droplets was 40 microns. The strength of the insecticides varied between 1 and 10 per cent, and the amount sprayed varied from 10 seconds to 4 minutes spraying time. In this way, for a given insecticide, at least four sprays and sometimes eight, were made at graded area deposits.

Fifty grasshoppers were exposed to each spray, and were observed for mortality daily during the following 3 days, although in the case of DNOC all significant contact mortality occurred within 24 hours. Control sprays were carried out with the solvents alone, which caused mortalities between 10 and 16 per cent in the residual sprays and zero and 10 per cent in the direct sprays. A correction was therefore made for the mortality figures on the basis of 9 per cent average control mortality (with the exception of benzene hexachloride in dioxane, for which a correc-

tion was made of 24 per cent control mortality). The density of deposit per acre was estimated colorimetrically by dyeing the spray with *Williams Red*, and catching it on two 4-inch petri dishes exposed alongside the biological material.

In the first part of the experiments, wheat foliage alone was exposed to the spray and clean grasshoppers were subsequently fed upon it. The results were therefore a measure of the stomach toxicity and the residual contact toxicity of the insecticide. The mortality figures for each insecticide at the graded doses, with the control corrections, were plotted on log-dosage probit-mortality paper; the median lethal deposit figure was read off as the density of deposit at which 50 per cent mortality could be expected. The figures for stomach and residual toxicity were:

Chlordane: Compound of empirical formula $C_{10}H_6Cl_8$; Technical product 90 per cent pure, dissolved in xylene and kerosene 1 to 3). Median lethal deposit 0.33 lbs. per acre for commercial product.

Benzene hexachloride: (Hexachlorocyclohexane, gamma isomer, 10 per cent gamma isomer content, dissolved in 1,4-dioxane). Median lethal deposit 7.4 lbs. per acre for commercial product.

DDT: (p,p'-dichlorodiphenyl-trichloroethane); 71 per cent p,p' content, dissolved in xylene-kerosene 1 to 4. Median lethal deposit 8.7 lbs. per acre for commercial product.

DNOC: (3.5-dinitro-o-cresol); Commercial product, dissolved in xylene-kerosene 1 to 2. Twenty-five per cent mortality at 6.8 lbs. per acre.

Phenothiazine (thiodiphenylamine); commercial, dissolved in xylene-*Mentor 29 Oil-acetone*, 1-3-2. Zero mortality at all densities up to 10.2 lbs. per acre.

In the second part of the experiment, the grasshoppers themselves as well as their food, were exposed to the spray. The results are primarily a measure of the direct contact toxicity of the insecticide. The grasshoppers were handled by first chilling them at 40°F. for 5 minutes, and then exposing them to the spray in battery jars (8″ high by 6.5″ diameter) ringed with vaseline. After the application the sprayed grasshoppers were caged on the sprayed wheat foliage and observed for 3 days. The results were plotted and the following median lethal deposits for direct contact toxicity were obtained:

	lbs. per acre
Chlordane, technical	MLD 0.10
DNOC, commercial	MLD 0.22
Benzene hexachloride, commercial	MLD 0.30
DDT, commercial	MLD 1.14
Phenothiazine	Ineffective

These results show that chlordane is an extremely powerful insecticide for the lesser migratory locust, being over twice as toxic by direct contact application, and over 20 times as toxic when applied as a residual spray, as any other insecticide tested. DNOC and benzene hexachloride are shown to be effective contact insecticides, with some residual effect for benzene hexachloride. DDT exhibited a surprisingly low contact toxicity.—12-30-46.

Aphid Barrier for the Laboratory

WILLIS N. BRUCE, *State Natural History Survey, Urbana, Illinois*

As a result of the inevitable difficulties encountered with a tanglefoot barrier, a resistance wire barrier was developed to confine aphids. Through a series of experiments with heat-gradient barriers, a barrier with the resistance wire imbedded ring was evolved. This apparatus is prepared by merely cutting a strip of plastic from a 0.09 inch stock into strips 0.75 in.×31 in. These strips are grooved near the one edge with a sharp instrument such as a scissors or a chisel. Into the groove is cemented a piece of No. 28 *Chromel* wire with a plastic glue. After this is dry the strip containing the wire is secured to a wooden form one foot in diameter and the ends are cemented together. The next step is to cement the ring with the resistance wire at the top edge onto a plate of glass. Twelve or 13 of these rings are connected in a series with 110 volts to consume about 0.7 amperes current and use approximately 75 watts per hour. In operation the heat produced is barely detectable with the hand but very repellent to the aphid or other small crawling creatures. The advantages of this barrier are quite apparent. There is no loss of insects due to escape or entanglement in the barrier. Aphids affected by toxicants will not cross the barrier. The barrier is permanent and easily cleaned with a damp cloth. Several species of aphids have been confined within this barrier successfully in trial tests—*Myzus porosus* (Sanderson), *Myzus persicae* (Sulz), *Rhopalosiphum rufomaculatum* (Wilson), *Clavigerus smithiae* (Monell), etc. Ants, firebrats, German roaches, etc., may be confied if the heat is increased by reducing the number of barrier rings in the circuit.

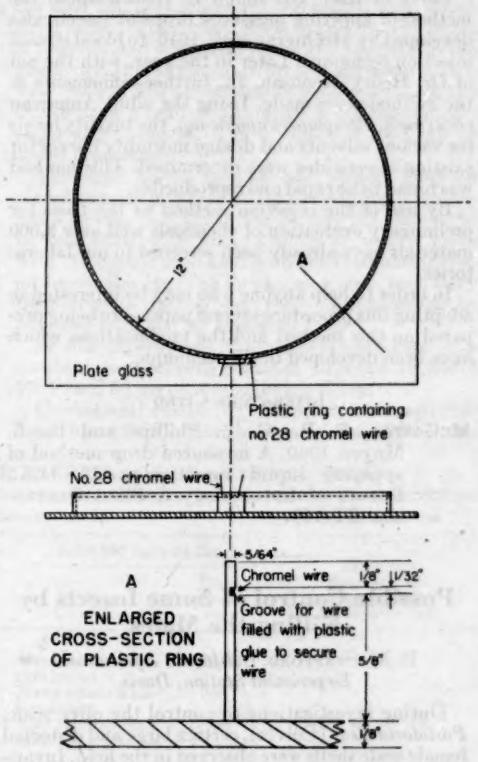

FIG. 1.—An aphid barrier for the laboratory.

Blood Stream Injection as a Preliminary Screen Test

BAILEY B. PEPPER, *Rutgers University, New Brunswick, N. J.*

The considerable interest demonstrated in methods of evaluation of insecticides at the recent meeting of the Association makes this an opportune time to present a note concerning the blood stream injection method developed at Rutgers.

Difficulties with existing screening methods led the late Dr. Thomas J. Headlee to suggest the possibility of injection of chemicals directly into the blood stream for the evaluation of potential insecticidal activity. He believed that this would by-pass initial consideration of the permeability of the insect cuticle to unknown materials as well as the factors involved in chemical penetration of the insect-gut.

Early in 1940, Dr. Ralph E. Heal adapted the method of applying measured drops of insecticides developed by McGovran *et al.* 1940 to blood stream injection technique. Later in the year, with the aid of Dr. Henry Menusan, Jr., further refinements in the method were made. Using the adult American cockroach, *Periplaneta americana*, the toxicity levels for various solvents and dosage mortality curves for existing insecticides were determined. This method was found to be rapid and reproducible.

By use of the injection method as the basis for preliminary evaluation of chemicals well over 3,000 materials have already been screened in our laboratories.

In order to help anyone who may be interested in adopting this procedure several papers are being prepared on this method and the modifications which have been developed in the technique.

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Possible Control of Some Insects by Killing the Males

E. M. STAFFORD, *California Agricultural Experiment Station, Davis*

During investigations to control the olive scale, *Parlatoria oleae* (Colvée), certain large and distorted female scale shells were observed in the field. Invariably these distorted female scales were found beneath spider webs on the leaves. In seeking an explanation for the presence of such abnormal individuals the following experiment was performed. In the spring of 1943 a twig of Italian jasmine was brought to the laboratory and infested with olive scale. As soon as the males could be recognized, (long before their emergence as adults), they were removed from the plant. The plant, infested only with females which were never fertilized, was isolated in a glass cylinder screened with fine mesh cloth.

The female scales matured normally on the caged plant. The formation of shell, however, did not cease after reaching the normal shape and size. Further increase in size was accomplished in various ways. Sometimes the normal shape was more or less retained. More often the formation of large lobes destroyed the symmetry of the shell and frequently the additional shell was laid down as a long band. The female scale bodies retained their normal shape but no eggs were formed. Often the females worked themselves completely outside of their shells. The females remained alive nearly all summer while normally the first brood females die in mid summer.

Single spray applications of any of the common DDT formulations have been unsatisfactory for control of olive scale and the crawlers are apparently able to establish themselves on DDT sprayed p'ants. On the other hand, DDT shows great promise for the control of black scale, *Saiessetia oleae* (Bern.), a common and serious pest of olives. In 1946 in an experiment to control black scale two applications of a dust containing 5 per cent DDT, 88 per cent sulfur and 7 per cent inert material were made at the rate of approximately 200 pounds per acre. The first application was made on July 11 and the second on August 1. An examination on October 1 revealed the presence of a large number of distorted female olive scale shells beneath which were found mature females which had laid no eggs. In some instances the females had emerged from beneath the distorted shells. The inference drawn was that the DDT dust killed the male scales but not the females.

Counts made on fruit, leaves, and twigs showed 98, 45, and 15 per cent of the mature females were abnormal, respectively. Since most of the females were found on the twigs the net result was that only 32 per cent of the live mature females showed distorted shells. In the fruit and leaves well over 90 per cent of the males that had not emerged were dead. Live males appeared to be in the second instar while the dead males were mostly in the pupal stage.

Though no satisfactory control of olive scale was attained, the occurrence of such a significant per cent of non-gravid females suggests the unusual approach to insect control, arrhenicidal control, or killing of the males. This would only be possible, of course, where parthenogenesis did not occur, and the possibility of such control would be greatly lessened by the occurrence of arrhenotoky. Such control would depend, on factors favoring the greater ease of killing the male insects. In the case of the DDT-dusted olive scale, it may be that the males were killed after they emerged and moved about thus coming into contact with the poison. On the other hand, males are more strongly chitinized than females and Richards & Cutkomp have shown that presence of chitin is favorable for DDT toxicity.

Sometimes DDT appears to give only slight or no control of an insect, followed by an increase in numbers. If the applications were made before the emergence of the males and if DDT showed effective toxicity to the males only, then additional applications of DDT would eventually control the insect. If the DDT were not present at the proper time or over a long enough period of time, its control of the natural enemies of the insect might be greater than the control of the pest for which it was applied. In such case a the net result would be an increase of the insect pest.—11-29-47.

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Six-Spotted Mite on Avocado

HOWARD T. OLDHAM and FRED T. THORNE, *San Diego County Agricultural Department, San Diego, California*

The discovery of a moderate infestation of *Tetranychus sexmaculatus*, Riley on avocados at Carlsbad, California, in August, 1946, is apparently a new host record for this species. This mite is a common pest of citrus in the coastal areas of Southern California, in Florida, and in the Gulf states.

While avocados have been planted adjacent to citrus groves here for years, this is the first case observed of this mite occurring on avodacos. Determination was made by Dr. E. A. McGregor, U. S. Bureau of Entomology and Plant Quarantine, and by H. H. Keifer, California State Entomologist.

The characteristic depressions produced on citrus leaves were not formed on avocado leaves, possibly due to the more rigid nature of the latter. Feeding was primarily confined to the under surface of the leaf and darkened, scarred areas were formed without appreciable buckling.

When first observed, the mites were causing slight damage, but the population subsided from natural causes, and by October had declined to a point where it was of no economic importance. A predaceous mite of the family Parasitidae was observed among the six-spotted mites.—11-20-46.

Rearing Clothes Moth and Black Carpet Beetle in the Laboratory[1]

MYKOLA H. HAYDAK, *University of Minnesota, St. Paul*

For rearing the clothes moth, *Tineola biselliella* Hum., and the black carpet beetle, *Attagenus piceus* Oliv., usually the technic described by Heal (1942) or a modification of it is used. In this article the technic and the foods used for rearing these insects in our laboratory are described.

For oviposition the adult clothes moths are etherized and then placed either in gallon cans with provisions for oviposition as suggested by Heal or, especially if only maintenance of culture is desired, in pint, wide-mouth Mason jars in which 3 or 4 pieces of woolen cloth (3 by 3 inches) are loosely placed (one on the bottom, the rest along the sides). The jar is closed with filter paper and fastened with a screw type rim. The moths are allowed in oviposit for 3 or 4 days, then etherized, taken out and destroyed. The woolen pieces are taken out, about a quarter of an inch layer of food is poured into the jar, a piece of the cloth with the eggs is spread over it, then half an inch of food is poured again and another piece of the cloth with eggs is placed on top of the food and this procedure is repeated until about 1.5–2 inches of free space is left in the jar. The latter is then covered with filter paper and fastened in the usual way. It is advisable to protect the paper with a wire cloth of fine mesh because before pupation the larvae have a tendency to gnaw holes through the paper and to escape. A new supply of food can be added if necessary.

The carpet beetles need not be etherized. They are placed in a jar prepared as for the rearing of clothes moth larvae. In starting the culture the jar should be half filled with food, a piece of woolen cloth with the eggs is sprinkled with the food and placed on top in the jar. The larvae, as a rule, soon bury themselves in the food and the woolen piece can be removed from the jar sometime later.

In our experiments the cultures were kept in a constant temperature chamber adjusted to about 77° F. and 60 per cent relative humidity.

Commercial casein (*CC*), expeller processed soybean flour (*SBF*), dried brewers' yeast (*DBY*), and

[1] Paper No. 577 Miscellaneous Journal Series, Minnesota Agricultural Station, St. Paul 1, Minnesota.

Table 1. Development of carpet beetle and clothes moth on various diets.

Food Composition and No. of Diet	Carpet Beetles					Clothes Moths	
	After 180 days on diet			After 365 days on diet			
	Length of larvae mm.	Passed through Sieve 20	Food consistency	Colony Condition	Food consistency	Minimum development. Egg to adult. F_1 days	F_2 days
CC, SBF, DY, DEY							
13	7–10	None	Soft	Many adults & mature larvae	Soft		
14	8–10	None	Soft	Many adults & mature larvae	Soft		
15	8–10	None	Soft	Very many adults & some mature larvae	Soft	43	46
SBF, DY, DEY							
16	7–9	None	Somewhat caked	No observations		41	41
SBF, CC, DY (15%)							
19	4–9	Many	Soft	Adults, mature and immature larvae	Soft		
21	5–8	Many	Soft	Adults, mature and immature larvae	Soft		
SBF, CC, DY (20%)							
20	5–9	Few	Soft	Adults, mature and immature larvae	Soft		
22	5–9	Few	Soft	Adults, mature and immature larvae	Soft		
SBF, DY							
17 (15% DY)	3–4	All	Caked	Few 3–4 mm. long larvae	Moderately caked	52	50
18 (20% DY)	—	Not tested	—	—	—	41	41
SBF alone	3–4	All	Slightly caked	Few 3–4 mm. long larvae	Caked	49	100

dried egg yolk (*DEY*) were used as food for rearing the insects. The results of these trials are given in table 1.

On the basis of these results it is suggested that a diet consisting of soybean flour, 65 parts, commercial casein, 20 parts, dried brewers' yeast, 10 parts and dried egg yolk 5 parts by weight be used for rearing the black carpet beetle and the clothes moth larvae. Mixtures of soybean flour 85 parts, dried brewers' yeast 10 parts and dried egg yolk 5 parts or soybean flour 80 parts and dried brewers' yeast 20 parts by weight can also be used for rearing the clothes moth larvae.

It is of interest to note that, according to Fraenkel (1943), *Dermestes vulpinus* does not grow on ergosterol or sitosterol. Our experiments with *Attagenus piceus* indicate that cholesterol is probably also required for the growth of the latter, because the addition of the dried egg yolk (containing cholesterol) to the diet having both sitosterol and ergosterol was necessary for normal development of these beetles.—2-15-47.

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Leaf-Disk Technique for Laboratory Tests of Acaricides

E. H. SIEGLER, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Because of their small size, their abundance under favorable conditions, and at times their rapid movement on the host plant, phytophagous mites are difficult to handle in experimental work. To evaluate the acaricidal effectiveness of spray materials, counts to determine mite mortality must be made with a binocular microscope. Therefore it is necessary to choose host samples on which the mite population is small enough so that the mites can be counted with a high degree of accuracy. As a means of conducting tests in the laboratory the writer has devised a method which he has called 'leaf-disk technique.'

To provide a source of mite material the two-spotted mite, *Tetranychus bimaculatus* Harvey, is reared in a greenhouse on bush lima beans. A leaf is removed from the plant and a suitably infested area is placed on a cork cutting block and cut out by means of a short cork borer having a diameter of .87 inch. The leaf disks, usually five per test, are placed in a petri dish, and then removed, one at a time, with forceps and immersed in the stirred test material for a period of 3 seconds. After treatment, the disks are returned to the petri dish, which is provided with moist cotton, and held until examined for counts of mites (nymphs and adults) alive or dead. Ovicidal data can be obtained at the same time if eggs are present.

Table 1. Typical results obtained with leaf disk technique in laboratory tests of acaricides.

MATERIAL AND DOSAGE (QUANTITY PER 100 GAL.)	DISK NO.	NUMBER OF MITES	
		Alive	Dead
Lime-sulfur (conc.), 2 quarts plus *Dreft*, 8 ounces	1	1	11
	2	2	18
	3	0	16
	4	1	17
	5	4	24
	Total	8	86
Dreft, 8 ounces	1	15	3
	2	12	2
	3	22	2
	4	21	1
	5	4	11
	Total	74	19
Distilled water (check)	1	19	4
	2	24	0
	3	19	4
	4	22	1
	5	26	1
	Total	100	10

Certain data selected to illustrate the uniformity of the results obtained with the leaf-disk technique are given in table 1. The disks were immersed on May 22, 1946, and the results were taken two days later.—12-23-46.

NOTICE TO CONTRIBUTORS

The Committee on Insecticide Nomenclature of the Association has approved the following names for JOURNAL use:

Chlordane, Benzene Hexachloride and gamma-benzene hexachloride. Since these names are well understood and already in general use this action will constitute a very welcome authorization for their continued use.

JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 40 April, 1947 No. 2

Where Do We Go from Here?

Doctor Clay Lyle, retiring president of the American Association of Economic Entomologists, in an editorial in the December, 1946, number of the JOURNAL, commented briefly on the trend in industry of present day entomology. He pointed out that a much larger proportion of entomologists attending the Richmond meetings were there as representatives of commercial concerns than was the case just a few years back. This shift of entomologists has been at the expense of the Federal and State services and the Colleges and Universities. As Dr. Lyle points out, in most cases the vacancies left in the institutions can not be filled with men of comparable training and experience.

The shift from institutional work to commercial work is not limited to entomologists. The same thing has been going on, though perhaps to a less degree, in the ranks of Plant Pathologists, Horticulturists and Chemists. This situation is bound to affect the institutions losing their personnel and raises problems that need discussion and solution if the two groups are to work in harmony for the progress of the profession.

Officially, there is no distinction between a commercial entomologist and an entomologist employed by the State or Federal services and the Colleges and Universities. And that is as it should be. Yet, in transferring from institutional work to commercial work, most entomologists fall down in their contributions to the profession as judged from their publications in scientific journals, bulletins and elsewhere. In their new positions, with more funds, better equipment and more modern laboratories, these investigators should turn out more and better work. But where and how are the rest of us to gain access to this information?

An examination of the membership list of the American Association of Economic Entomologists will show that well over a third of the members are connected with industrial concerns, yet the papers published in the JOURNAL are 90 per cent or more from institutional workers. Take the Eastern Branch of the Association. A check of those paying dues and registration fees at the November, 1946, meeting in Baltimore discloses that between 40 and 50 per cent were associated with industrial concerns. Yet, if we examine the program of papers presented we find only two out of some 30 odd submitted came from investigators associated with industry. The same situation existed the year before at the Eastern Branch meeting in New York.

An even more glaring example of the failure of the commercial men to contribute can be cited in the case of the pool of information on the codling moth. This pool of information has been assembled by the Committee on the Codling Moth of the Association for the past 10 or 12 years. Investigators working for commercial concerns are invited to contribute data and observations, yet not a single contribution from them is to be found in the current pool of information. Institutional workers in the various states, the Federal agencies, Canada and Australia are included, but nothing from the commercial investigators. It isn't that they aren't carrying on investigations and making observations, because in New Jersey alone there are a half dozen different concerns carrying on research on the codling moth and related problems. It would seem, therefore, a fair question to ask why the lack of cooperation and how we can induce these entomologists to contribute to the common effort.

It has been suggested that perhaps we should leave the development and testing of new insecticides and fungicides to the industrial investigators; that the official investigators (State and Federal) should sit back and umpire the game; decide on

the validity of the various claims of the commercial people and, for the most part, let the commercial interests support the official institutional investigators. As a matter of fact, much of the development and testing of new pest control materials is being done by industry. Many institutional workers have become mere testers of products and formulations devised by the commercial men. And suppose we do let the official investigator act as umpire; he still needs an adequate staff, laboratory facilities and equipment to do the job. There are literally dozens of brands of DDT and the same will be true of benzene hexachloride, hexaethyltetraphosphate and others, to say nothing of the newer and more special products such as chlordane and toxaphene which will need evaluating. Umpire? Why, I know of one official investigator in an eastern state who, as late as the season of 1946, was depending upon a sprayer which had been thrown away by a grower 10 years ago, to test pest control materials. This investigator patched up the discarded machine and has been worrying along with this antique for 10 years!

It has been my observation that more and more of our fruit growers are depending on commercial men for advice and guidance in their insect and disease control problems. And why not, when the commercial men are, in many instances, better prepared to arrive at the answers promptly than the official investigator. These commercial investigators have well staffed laboratories, equipped with the latest and best equipment. They work right along with the growers, where the problems are more or less in competition with the institutional worker. Moreover, their technical service men and salesmen visit many of the growers frequently and study the problems of the individual grower. Furthermore, the larger concerns maintain laboratories scattered throughout the country. A new mite control material, for example, if it shows promise in an eastern apple orchard can be quickly checked in Florida, California, Washington and points in between. The institutional worker, on the other hand, has to wait for his fellow institutional worker in other sections to publish; or perhaps they get together in regional conferences or in pools of information such as the one on the codling moth. Perhaps we need more pools of information patterned along the lines of the Codling Moth Pool.

This problem of the commercial investigator and the institution investigator operating in the same field has been handled in recent years in New Jersey by the two groups getting together. For the past several years, when the extension specialists sit down in the fall with the entomologists, plant pathologists and horticulturists to revise spraying recommendations for the next season, the research men of the commercial concerns doing research in the state are invited in to participate in the discussions and revisions. Spraying recommendations and revisions are based on the data and observations of both groups, although the final revisions put out are the responsibility of the Agricultural College and Experiment Station workers.

It has been suggested that industrial concerns should support the institution workers; and they do. Many of our agricultural colleges and experiment stations are practically bursting at the seams trying to handle commercial grants and fellowships. I know of one department normally supported by Federal and State funds where more money is handled from commercial sources than from Federal and State sources combined. In this same department there is a class of 10 advanced students, two of whom are supported by institutional funds while eight obtain their stipend via commercial sources.

I do not want to give the impression that I am against this development or trend. Certainly more funds and equipment are thus made available to the department concerned and, theoretically, more research should result for the betterment of all concerned. But does this follow? Not necessarily or at least not immediately. Much of this commercial support has strings attached. Many of the contracts have clauses inserted reserving the right of the donor to withhold or delay publication of data or to patent discoveries made in the course of the investigations. Eventually everybody benefits, no doubt, but certainly the primary beneficiary is the sponsoring concern. The more this type of work is done and funds accepted the less time there will be for institutional workers to direct work strictly of a public nature. It would seem also that in time it will become more diffi-

cult to obtain public support for tax funds to carry on institutional work of this nature.

Perhaps one solution to the problem would be for industrial concerns to subsidize more liberally the institutions and with less strings attached. An example of this is the Thomas J. Headlee research fellowship fund established at Rutgers University and supported mainly by funds donated by industrial organizations. The income from these funds is used to support a graduate student who works in the field of pure entomology. The present holder of the fellowship happens to be working on the general problem of how insecticides kill and is not limited in any way to any particular insecticide or particular concern's products. More of this kind of support is needed from industry.

There appears to be a need or demand for disinterested investigators whose only interest is to find the best and cheapest method or material to control a given pest. However, with the numerous new compounds on hand and other new ones emerging almost daily, the institutional worker is hard put to it to keep abreast of new developments to say nothing of testing and evaluating different commercial products. Some of the institutional leaders in fruit pest control work are kept busy as one armed paper hangers running laboratory and field experiments during the growing season. During the fall and winter season, when normally they would be summarizing their data for publication, they are in demand at various growers meetings and conferences to present their latest findings. In one instance that came to my attention the findings presented at a meeting by one of these workers were copied and published by someone else before the investigator himself had a chance to publish them.

As a concluding thought, if there is a need for disinterested institutional investigators to evaluate impartially the various pest control products, some means will have to be worked out so that they will have adequate facilities and help for doing the job. The other alternative is for industry to take over the development, testing and promotion of new pest control materials and for the institutions to turn to fundamental research and the training of students.

BYRLEY F. DRIGGERS

OBITUARY

Kenneth Barbee McKinney 1890–1946

Kenneth Barbee McKinney was born in Lincoln County, Tennessee, September 15, 1890, and died on August 22, 1946, at his home in Tempe, Arizona. His early education was obtained at Morgan's Preparatory School, Fayetteville, Tenn., and in 1916 he received the degree of Bachelor of Science at the University of Tennessee.

During the summer seasons of 1913 and 1915, and most of the period from 1916 to 1928, he was engaged in investigations on insects affecting burley and dark fire-cured tobacco with headquarters at Clarksville, Tennessee. For a part of this period, however, he was engaged in investigations on cotton insects with the Federal Horticultural Board. This included work performed in Mexico. In the course of his work on cotton insects, Mr. McKinney was the first individual to find the pink bollworm in gin trash in the United States. This discovery contributed greatly to the fund of knowledge which demonstrated later that gin trash was a good source from which to collect the pink bollworm and led ultimately to the development of the gin trash machine by other workers. This machine is now used extensively to determine the presence of the pink bollworm in domestic cotton plantings, and is especially valuable in delimiting pink bollworm infestations in new areas.

In 1928 he was assigned to a study of the biology and control of the tobacco stalk borer at Tempe, Arizona, since this insect had become an important limiting factor in the attempt to produce tobacco of high nicotine content for use in preparing insecticides. Beginning in 1934, and until his death, he was engaged principally in investigations of insects affecting truck crops, first with headquarters at Tempe and later at nearby Phoenix. These investigations were centered chiefly on the biology and control of the cabbage looper and beet armyworm as pests of lettuce, the squash capside on cucurbits, and on Lygus bugs, the Say stink bug, and associated insects attacking sugar beets grown for seed. Outstanding among his publications are Farmers' Bulletin No. 1489 "The Green June Beetle Larva as a Pest of Tobacco in Plant Beds" (with Joe Milam); Technical Bulletin No. 846, "The Cabbage Looper as a Pest of Lettuce in the Southwest; J.E.E., Vol. 32 (6) "Common Insects Attacking Sugar Beets and Vegetable Crops in the Salt River Valley of Arizona," and Bulletin 918 (Proff. Paper) "Report on Investigations of the Pink Bollworm of Cotton in Mexico" (with U. C. Loftin and W. E. Hanson).

His principal hobby for many years was fishing and in the pursuit of this activity he visited practically all of the choice fishing sites in the lower inter-

mountain region. He made his own lures for both trout and bass. Incidental to his other activities Mr. McKinney made quite an extensive collection of desert rocks as well as Indian relics taken from prehistoric camp sites and cliff dwellings.

On October 10, 1940, Mr. McKinney was married to Nora Elkin of Clarksville, Tenn., who survives, together with two newphews John H. and Jerry McKinney of Fayetteville, Tennessee.

D. J. CAFFREY AND W. H. WHITE

A HISTORY OF ENTOMOLOGY IN RELATION TO WORLD WAR II[1]

The American Association of Economic Entomologists and the Entomological Society of America, at the annual meetings held in Richmond, Virginia, in December 1946, passed resolutions for the appointment of a joint committee to prepare a history of entomology in relation to World War II.

The assembling of data from which to compile an accurate account of the part played by entomology in the war is an enormous undertaking, and its successful completion will require the active cooperation of all concerned. Information is desired concerning your entomological activities during the war period, and a questionnaire is enclosed to serve as a guide in the submission of this information. Any additional pertinent information not called for in the questionnaire is solicited. The completeness and accuracy of this history will largely depend upon the data furnished by contributors. It is therefore requested that you give this matter your careful consideration and submit the information as promptly as possible.

THE JOINT COMMITTEE FOR THE PREPARATION OF A HISTORY OF ENTOMOLOGY IN RELATION TO WORLD WAR II.

Send reply to:

Edward F. Knipling,
Bureau of Entomology and Plant Quarantine,
U. S. Department of Agriculture,
Washington 25, D. C.

QUESTIONNAIRE ON ENTOMOLOGICAL CONTRIBUTIONS DURING WORLD WAR II

1. Name of institution or organization.
2. Nature of entomological work having a direct bearing on the protection of military personnel or supplies.
   a. List of projects and nature of work.
   b. Names and titles of personnel assigned.
   c. Duration of project, including dates work was initiated and terminated.
   d. A brief summary of important developments.
   e. List of more important publications or articles in preparation resulting from work at your institution during the war and falling under section 2 of this questionnaire.
3. Nature of entomological activities having a direct bearing on the war effort but not necessarily for the protection of military personnel or supplies. Include such items as training of service personnel, activities of direct importance to the national economy, etc. List major projects, duration, number of personnel assigned, and give a brief summary of developments.
4. Names and present addresses of entomologists with your institution or organization who entered service during the war. (Special questionnaires are being sent to armed forces personnel.)
5. Remarks. Any other pertinent information of possible interest in connection with the preparation of a history of entomology during World War II.

Send reply to:

P. W. Oman,
Bureau of Entomology and Plant Quarantine,
U. S. National Museum,
Washington 25, D. C.

ENTOMOLOGICAL ACTIVITIES QUESTIONNAIRE ARMED FORCES PERSONNEL

1. Name
2. Service (Army or Navy)
3. Period of service
4. Grade or rank (initial and final)
5. Reserve status
6. Decorations (include citation if possible)
7. If present address is subject to change, give address where you can always be reached
8. List papers published or in process of publication on the work you did during the war
9. Criticisms of the utilization of entomologists during the war, and suggestions for the future
10. Narrative account of war service, including dates, localities, nature of duties, accomplishments, etc. (activities of individual or entomological unit to which assigned)

(Use additional sheets as needed)

[1] The above form letter and questionnaires are published in an effort to contact all individuals and organizations concerned in the indicated project. All entomologists not contacted, either directly or through their organization, are urged to reply to the appropriate questionnaire.

PROCEEDINGS OF THE EIGHTEENTH ANNUAL MEETING

EASTERN BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS,

Lord Baltimore Hotel, November 21 and 22, 1946

The Eighteenth Annual Meeting of the Eastern Branch, American Association of Economic Entomologists, was called to order by the Chairman, H. F. Dietz, at 10:00 A.M. November 21, 1946 in the Lord Baltimore Hotel in Baltimore, Maryland. Doctor Dietz, assisted by the Vice-Chairman, Doctor J. O. Pepper, presided over the 2-day meeting which was devoted to the presentation and discussion of 31 papers. On the afternoon of November 22 a round table discussion "Aerosols and Particle Size" was held with Dr. R. D. Glasgow as the leader.

At the end of the morning session on November 21, Doctor Dietz appointed the following committees:

Nominations: F. W. Poos, R. W. Dean, J. L. Horsfall
Auditing: James L. Brann, Jr., Harry G. Walker
Resolutions: B. B. Pepper, Philip Garman, T. W. Reed

REPORT OF THE SECRETARY-TREASURER

Notices of the eighteenth annual meeting to be held in Baltimore on November 21 and 22, 1946 were sent out to approximately 700 members of the American Association of Economic Entomologists residing in the eastern territory. A total of 31 paper titles were received which is about 12 less than was received for the 1945 meeting held in New York City. Dues paying members for 1945–1946 amounted to 185.

The seventh or 1945 annual award for the most outstanding paper presented at the meeting went to Doctor Neely Turner of the Connecticut Agricultural Experiment Station for his paper "Diatomaceous Diluents for Dusts" published in the April, 1946 issue of the JOURNAL OF ECONOMIC ENTOMOLOGY.

FINANCIAL STATEMENT

Balance on hand, November 28, 1945		$2,316.09
Receipts		
Dues for 1945 after November 28, 1945	$ 242.00	
Dues for 1946 to November 15, 1946	152.00	
Sale of *Entoma* (4) at New York meeting	4.00	
Receipts from *Entoma* 1946	1,800.00	
Total receipts	$2,198.00	4,514.09
Disbursements		
Hotel New Yorker, services	.80	
King Cole's Sound Service (Projection Equipment)	75.00	
Payment to Secretary-Treasurer, 1946	200.00	
Payment to Editor of *Entoma*, 1946	500.00	
Clerical Services		
Eastern Branch	38.28	
Entoma	99.83	
Postage and Envelopes		
Eastern Branch	41.00	
Entoma	313.50	
Expenses, Secretary-Treasurer	21.00	
Annual Award	75.00	
Engraving	2.50	
Dues Returned (double payment)	12.00	
Total disbursements	$1,378.91	
Balance on hand, November 15, 1946		$3,135.18
Distributed as follows:		
Checking Account, The Union National Bank and Trust Company, Mount Holly, N. J.		3,175.08
Less outstanding checks:		
10/7 Geo. S. Langford	45.00	
11/7 Helen Bewley	4.90	49.90
		3,125.18
Cash on hand in office		10.00
		$3,135.18

BYRLEY F. DRIGGERS
Secretary-Treasurer

REPORT OF EDITORIAL COMMITTEE ON *Etoma*

The editorial committee recommended that the seventh edition of *Entoma* be brought out in 1947. The committee authorized the Editor to increase the rates to advertisers to take care of the increased costs incident to getting out a publication of the type of *Entoma*. It was suggested that the new Chairman appoint a new committee on *Entoma* with the advice of the Editor. The Editor submitted the following summary of the business activities incident to getting out the 6th edition of *Entoma*.

SUMMARY

BUSINESS ACTIVITIES—6TH EDITION OF *Entoma*

Sales		
Advertising—Sixth Edition (paid)		$5,139.59
Paid listings		279.00
Entoma sales		1,650.74
		$7,059.33
Expenses		
Stationery, envelopes, circulars, etc.	$ 254.25	
Printing *Entoma*	3,641.29	
Clerical help and Notary fees	355.43	
Freight bills ($2.95 unpaid)	10.97	
Stamps	675.00	
Telephone bills (not paid)	6.72	
Honorarium to Editor	500.00	
	$5,443.66	
Net profit or income—November 15, 1946		$1,615.67
Status of Funds Received		
1. Total funds received		$7,059.33
2. Distribution of funds		
a. Transferred to Eastern Branch	$6,800.00	
b. On deposit—Prince Georges Bank and Trust Company	257.23	
3. Cash on hand	2.10	
		$7,059.33

REPORT OF AUDITING COMMITTEE

November 21, 1946

The Auditing Committee has examined the accounts of the Secretary-Treasurer and the Editor of *Entoma* and has found them to be correct and in good order.

JAMES L. BRANN, JR.
HARRY G. WALKER

REPORT OF COMMITTEE ON RESOLUTIONS

Your Committee desires to present the following resolutions:

(1) Whereas there is great confusion regarding the proper designation of the new insecticide $C_6H_6Cl_6$, be it resolved that the Eastern Branch recommend to the National Organization—The American Association of Economic Entomologists—that (1) immediate steps be taken to give to the membership an official name for the compound variously designated as "Hexachloro-cyclohexane," "Benzene Hexachloride," "Gammexane" and "666," and that said official name be recommended to the exclusion of all others; (2) that a short name or abbreviation similar to DDT for use among farmers and others be proposed by the same body or committee designated to consider the matter.

(2) Whereas there is considerable confusion regarding the health hazards of the newer organic insecticides such as DDT, Benzene Hexachloride and Hexaethyl Tetraphosphate.

Be it resolved that the Eastern Branch of the American Association of Economic Entomologists urge the Federal and State agencies concerned to clarify speedily the poisonous nature of these new insecticides for the benefit of those who have the responsibility for making recommendations for their use in Agriculture.

(3) Whereas the present meeting of the Eastern Branch is the first meeting not attended by our former Secretary-Treasurer, Mr. Harry B. Weiss, owing to the illness of Mrs. Weiss,

Be it resolved that the members of this organization extend to him our regrets for this misfortune, and wish Mrs. Weiss a speedy recovery.

(4) Whereas the Almighty has taken our good friend and member, Doctor Thomas J. Headlee, one of the founders of the Eastern Branch, from our midst on June 15, 1946.

Be it resolved that we extend sympathy to his family and that a copy of this resolution be spread on the minutes of the Eastern Branch.

(5) Whereas the Almighty has taken our esteemed member, Mr. B. H. Walden,

Be it resolved that we extend sympathy to his family and that a copy of this resolution be spread upon the minutes of the Eastern Branch.

(6) Whereas the Almighty has taken from our midst our fellow member, Dr. John Austerland, since our last meeting.

Be it resolved that we extend sympathy to his family and that a copy of this resolution be spread upon the minutes of the Eastern Branch.

(7) Whereas the Eastern Branch has been so well accommodated during the present meeting,

Be it resolved that the Eastern Branch extend its thanks to the management of the Lord Baltimore Hotel and to the Chairman of our local committee on arrangements, Mr. A. E. Badertscher, for the work involved in completing the arrangements.

REPORT OF NOMINATING COMMITTEE

Your Committee proposes the following persons to serve as officers of the Eastern Branch of the American Association of Economic Entomologists for the coming year.

For Chairman: J. O. Pepper

For Vice-Chairman: C. M. Packard

F. W. POOS J. L. HORSFALL,
R. W. DEAN *Chairman*

Between 300 and 400 attended the two day meeting and the following members and guests registered.

Adams, J. Alfred
Adams, J. F.
Adler, Howard
Alexander, C. C.
Anderson, Lauren D.
Arnold, R. B.
Badertscher, A. Edison
Baker, Howard
Barthel, William F.
Beacher, John H.
Beard, Raimon L.
Beckman, H.
Bickley, Wm. E.
Billings, Samuel C.
Bishopp, F. C.
Blanton, Franklin S.
Bliler, Eleanor J.
Bodenstein, O. F. (Mrs.)
Bodenstein, William G.
Bowen, C. Verne
Bowery, Thomas G.
Boyd, Wm. M.
Brann, James L., Jr.
Brannon, Lloyd W.
Brian, Charles E.
Bromley, Stanley W.
Brooks, James W.
Brower, D. G.
Brunson, M. H.
Brunton, J. G.
Buchholz, J. H.
Buerger, Newton W.
Bunn, Ralph W.
Buntin, George
Burnside, W. H.
Bushey, Ruth L.
Carruth, L. A.
Carter, R. H.
Chisholm, Robert D.
Clancy, D. W.
Clark, Charles A.
Collins, Donald L.
Condron, Carl H.
Cornell, W. A.
Cooper, James F.
Cory, Ernest N.
Craig, F. Waldo
Crissman, William I.
Darley, Merrill M.
Dean, R. W.
Dewey J. E.
Dickinson, Berton C.
Dietz, Harry F.
Ditman, L. P.
Donohoe, Heber C.
Dove, Walter E.
Driggers, B. F.
Dutky, Samson R.
Dye, H. W.
Eastman, P. M.
Evans, J. A.
Farley, Arthur J.
Ferguson, George R.
Ferguson, Marvin H.
Feustel, William K.
Filmer, R. S.
Fleenor, Ernest B.
Fleming, Walter E.
Frear, Donald E. H.
French, G. Talbat
Frisby, Herbert M.
Fulton, R. H.
Gambrell, F. L.
Gemmell, L. G.
Gerberg, Eugene J.
Gesell, S. G.
Gilberg, Engel
Ginsburg, J. M.
Glasgow, Hugh
Glasgow, Robert D.
Glass, Edward H.
Goddin, A. H.
Goode, Louise
Gooden, Ernest L.
Granett, Philip
Grayson, James McDonald
Greenwald, Margaret
Greenwood, Douglas E.
Guy, H. G.
Guyton, T. L.
Hadley, C. H.
Haeussler, G. J.
Hall, Walter E.
Hamilton, Clyde C.
Hammer, O. H.
Hansens, Elton J.
Harman, S. W.
Harrington, George E.
Hartzell, Albert
Haude, W. J.
Haynes, Harry L.
Heal, Ralph E.
Hicks, Harold E.
Hill, C. C.
Hill, C. H.
Hinebauch, John W.
Horsfall, J. L.
Hough, W. S.
Hovey, Chas. L.
Hutchins, Francis E.
Jennings, Cedric C.
Johnson, Conrad C.
King, Jos. L.
Knipling, E. F.
Knutson, Herbert
Krafchick, Bernard
Langford, Geo. S.
Leiby, R. W.
Leonard, M. D.
Long, John C.
MacCreary, Donald
Maddrey, J. B.
Magram, Sidney T.
Mail, G. Allen
Manzelli, M. A.
Marvin, Philip H.
McAlister, L. C., Jr.
Menusan, H., Jr.
Merritt, James M.
Miller, A. C.
Miller, Jesse F.
Moore, Donald H.
Mulhern, Thomas D.
Nagel, Roy H.
Nash, Kenneth B.
Nelson, B. H.
Orr, Leslie W.
Packard, C. M.
Parker, L. B.

Pass, Herbert A.
Payne, Nellie N.
Pechuman, L. L.
Pepper, B. B.
Pepper, J. P.
Perinchief, M. K., Jr.
Peterson, P. D.
Pierpont, Roger L.
Poland, J. Lloyd
Pollard, Herschel N.
Poos, F. W.
Porter, Alex
Porter, B. A.
Ranck, W. A.
Reagan, E. P.
Reed, John P.
Reed, Lucius B.
Reed, T. W.
Reno, P. J.
Rex, E. G.
Ridgway, H. W.
Roark, R. C.
Rowell, J. O.
Sacktor, Bertram
Sanders, J. G.
Schroeder, Herman O.
Seiferle, Edwin J.
Shands, W. A.
Shepard, Harold H.
Siegler, E. H.
Singleton, J. M.
Sisson, H. A.
Skaptason, J. B.
Smith, C. L.
Smith, Floyd F.
Smith, L. E.
Soraci, Frank A.
Sorles, Merritt P.
Southwick, Lawrence
Squires, Delbert W.
Starnes, Ordway
Starr, Donald F.
Stearns, L. A.
Steiner, Harold M.
Sutton, Robert
Tate, H. Douglas
Thompson, Bayard T.
Thompson, Friar, Jr.
Toffaleti, James
Trembley, Helen Louise
Turnipseed, G. F.
Udine, E. J.
Valentine, Thor
Vandenberg, G. B.
VanGeluwe, John
Vierner, M. B.
Vincent, Rufus H.
Vinzant, J. P.
Walker, Harry G.
Wallace, Robert T.
Wallace, Philip P.
Watts, Carl N.
Webb, Joseph E., Jr.
Weigel, Charles A.
Welanetz, Ludolph F.
Westcott, Cynthia
Willey, C. R.
Wilson, Clifton A.
Wisecup, C. B.
Woodbury, E. N.
Woodruff, Nancy
Woodside, A. M.
Worthley, H. N.
Zappe, M. P.
Zukel, John W.

BYRLEY F. DRIGGERS, *Sec'y-Treas.*

SIXTH ANNUAL NORTHWEST VEGETABLE INSECT CONTROL CONFERENCE

The Sixth Annual Meeting of the Northwest Vegetable Insect Control Conference was held in Portland, Oregon, on January 20, and 21, 1947. This is a conference of State and Federal entomologists engaged in research or extension work on insects affecting vegetables in Idaho, Montana, Oregon, Utah, and Washington.

The first day was devoted to discussions by the members of the conference of problems connected with the control of vegetable insects. The following subjects were discussed: State and Federal relationships, publicity, airplane application of insecticides, and the status of DDT research.

On the second day representatives of the insecticide and vegetable crop industries were present, the subjects discussed on the previous day were reviewed and in addition the availability of insecticides for 1947 and new insecticides were discussed.

In the past the conference has not issued any formal recommendations for the control of vegetable insects. However, owing to the unusual demand, by both entomologists and representatives of the insecticide industry, for a statement on the use of DDT for pea weevil control, a committee was appointed which drew up the following recommendation which was approved by a vote of the conference.

"The use of 15–20 pounds of dust containing 5 per cent of DDT per acre applied in the same manner and under the same conditions as rotenone is recommended. The use of DDT is not recommended where pea ensilage or pea hay is to be fed to dairy cattle. In situations where it is desired that plant residues be fed to dairy cattle, it is recommended that rotenone-containing dusts be applied as formerly."

The executive committee in charge of arrangements for the 1947 meeting were R. L. Webster, Washington State College, Pullman, Washington, *Chairman;* B. J. Landis, U. S. Department of Agriculture, Union Gap, Washington, *Co-chairman;* and Tom A. Brindley, U. S. Department of Agriculture, *Secretary.*

The following executive committee was elected for the coming year: J. C. Chamberlin, U. S. Department of Agriculture, Forest Grove, Oregon, *Chairman;* H. C. Manis, University of Idaho, Moscow, Idaho, *Co-chairman;* and Dave Brannon, State College of Washington, Extension Service, Pullman, Washington, *Secretary.*

T. A. BRINDLEY, *Secretary*

TEXAS ENTOMOLOGICAL SOCIETY ANNUAL MEETING
SAN ANTONIO, TEXAS
MARCH 11 TO 13, 1947

The annual meetings of the Texas Entomological Society were held March 11 to 13, 1947 with headquarters at the Gunter Hotel. The several sessions were presided over by W. G. Bruce, President, O. D. Deputy, Vice-President and S. W. Bilsing, Past-President.

Twenty-five titles were listed on the program; all of these but one were presented, and Professor B. A. Slocum was delayed en route and thus prevented from appearing. One factor, more than any other, seemed to enhance the value of the program. That was the free and comprehensive discussions of the papers which followed their reading. Readers of the JOURNAL will have opportunity to study many of the items from the program which are scheduled for publication.

PROGRAM

TEXAS ENTOMOLOGICAL SOCIETY

Annual Address of President—Over the Horizon. W. G. BRUCE.

Cotton Insect Control with Benzene Hexachloride and a Mixture of DDT and Benzene Hexachloride. K. P. EWING, C. R. PARENCIA, JR., and E. E. IVY.

Control of Cotton Insects with Camphene 3956. E. E. IVY, C. R. PARENCIA, JR., and K. P. EWING.

Laboratory and Cage Tests with Some of the Newer Insecticides against Cotton Insects. E. E. IVY AND K. P. EWING.

Notes on Robberflies (*Asilidae*) Preying on Honey-

bees in the San Antonio area during 1946. A. H. ALEX.
Summary of Phony Peach and Peach Mosaic Control. A. E. CAVANAGH.
Concentration of DDT Sprays for the Control of Ectoparasites of Livestock. W. G. BRUCE and E. B. BLAKESLEE.
Preliminary Tests with DDT Sprays for the Control of the Gulf Coast Tick. E. G. BLAKESLEE and W. G. BRUCE.
Area Control of Chiggers in Experimental Plots. CARROLL N. SMITH and HARRY K. GOUCK.
Field Tests of Uniforms Impregnated with Mite Toxicants. H. F. CROSS and F. M. SNYDER.
The So Called "Tail-Louse" of Cattle in Florida. W. G. BRUCE, E. B. BLAKESLEE and A. N. TISSOT.
Studies of the Control of Onion Thrips, *Thrips tabaci* Linderman, in the Winter Garden Region of Texas. E. T. HIBBS.
Preliminary Investigations with the Aerosol Fog Machine in the Control of Vegetable Insects. GEORGE P. WENE.
The Place of Entomology in Extension. C. A. KING, JR.
Insecticides Tested for the Control of Cotton Insects in 1946. W. A. STEVENSON.
Hibernation of the Pink Bollworm in the Lower Rio Grande Valley of Texas and Mexico. L. C. FIFE, IVAN SHILLER and A. J. CHAPMAN.
Insecticides for Pink Bollworm Control. O. T. ROBERTSON.
Comparative Toxicity of Benzene Hexachloride and DDT to Thrips on Cotton and Onions. A. J. CHAPMAN, C. A. RICHMOND, and L. C. FIFE.
A Unique Cultural Control for the Pink Bollworm in the Lower Rio Grande Valley of Texas. A. J. ALDERDICE.
Tests against Body Lice with Compounds More Toxic Than DDT. GAINES W. EDDY and R. C. BUSHLAND.
Evaluation of Certain Selected Insecticides and Drugs as Chemotherapeutic Agents for the Control of External Bloodsucking Parasites, E. F. KNIPLING, R. C. BUSHLAND, F. H. BABERS, G. H. CULPEPPER and E. S. RAUN.
Techniques for Research on Insecticides as Chemotherapeutic Agents for Cattle Grubs. W. L. BARRETT, JR., and R. W. WELLS.
Field Studies with Insecticides for the Control of the Lone Star Tick. WM. C. MCDUFFIE.
The Treatment of 1036 Natural Infestations of Head Lice with DDT and Myl Louse Powders and the NBIN Louse Scabies Emulsion. GAINES W. EDDY.
Tabanid Control. CHARLES L. SMITH.
Current Research on Insects Affecting Man and Animals. E. F. KNIPLING.
Entomology in the Commercial Field, C. O. EDDY (Leader of Discussion)
Entomological Conditions in China, Professor B. A. SLOCUM, University of Nanking (not presented)

Officers

W. G. BRUCE, President, P.O. Box 78, Savannah, Georgia
O. D. DEPUTY, Vice-President, P.O. Box 909, Brownsville, Texas
L. F. CURL, Secretary-Treasurer, P.O. Box 798, San Antonio 6, Texas

Committee on Entertainment

WALTER T. MCKAY, Chairman, State Department of Agriculture, Austin, Texas
A. E. CAVANAGH, San Antonio, Texas
T. R. STEPHENS, San Antonio, Texas

Social features of the meetings arranged by the local committee were unique and enjoyable. The attendance, as will be seen in the list presented here, included professional and amateur entomologists, research men, extension specialists and a liberal representation of industry in its various entomological phases.

A list of those in attendance is appended.

L. F. CURL, *Secretary-Treasurer*

PEST CONTROL OPERATORS MEET AT PURDUE

The Eleventh Annual Pest Control Operators' Conference was held at Purdue University, Lafayette, Indiana, April 7 to 11, 1947, J. J. Davis in charge. There were 195 registrations from 20 states and Canada. Of this number 5 had attended all 11 conferences and 76 were here for the first time. During the 11 years 697 pest control operators have attended the conference. Aside from Purdue Entomology Staff Members, Willis N. Bruce of the Illinois State Natural History Survey and L. S. Henderson of the U. S. Bureau of Entomology and Plant Quarantine participated in the program as did G. C. Oderkirk, Milton Caroline, Tom Murray, and Ernest M. Mills of the Fish and Wildlife Service, and several pest control operators and authorities from commercial industries.